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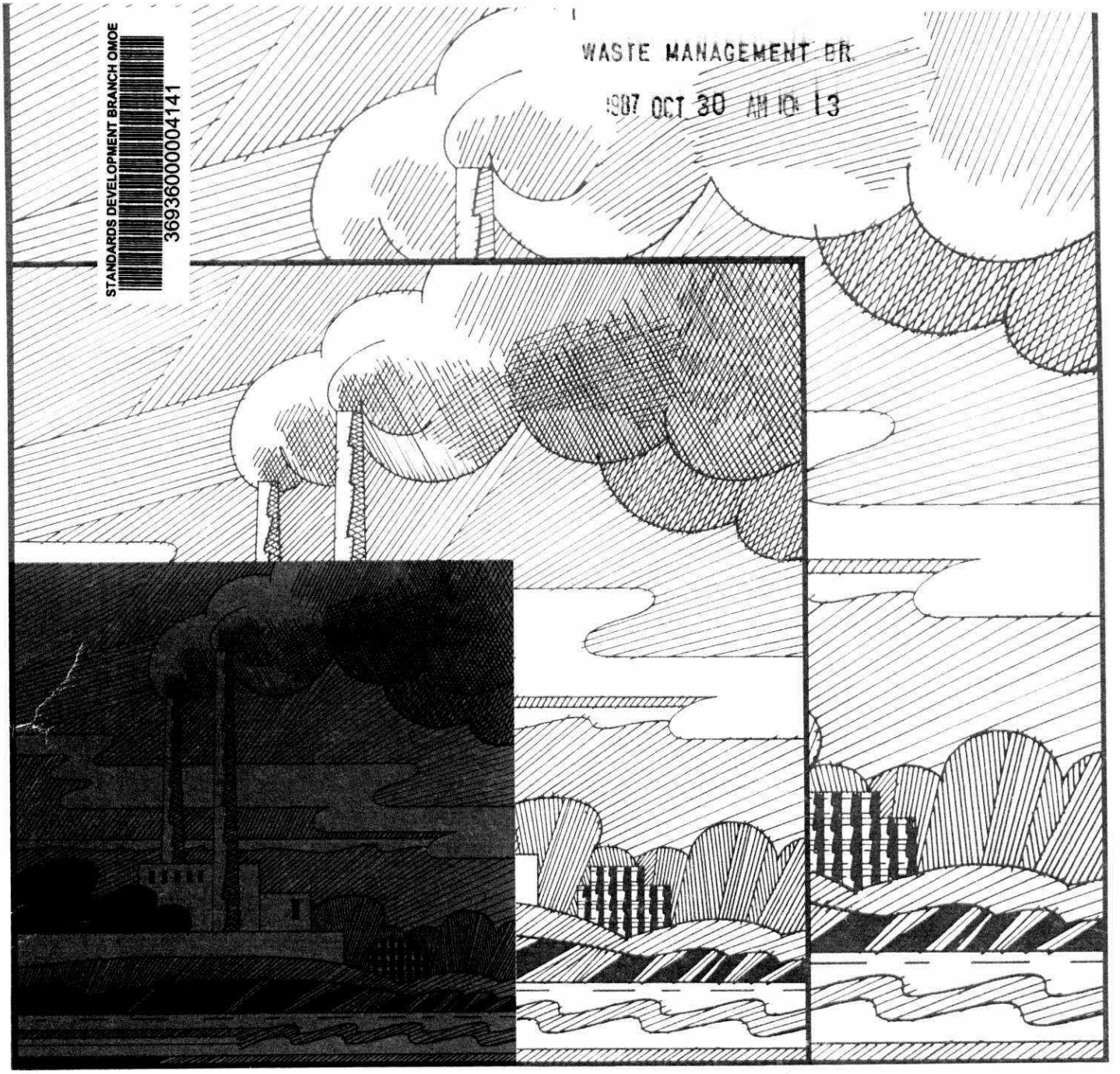

34th Ontario Industrial Waste Conference

June 14-17, 1987
Prince Hotel, Toronto

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Proceedings

Environment Ontario

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Proceedings
of the
Thirty-fourth
Ontario Industrial Waste Conference

held at

The Prince Hotel
Toronto, Ontario

June 14-17, 1987

Sponsored by the
Ontario Ministry of the Environment

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PREFACE TO THE PROCEEDINGS OF THE 34th ONTARIO INDUSTRIAL WASTE CONFERENCE

Four hundred and twenty-two delegates and spouse attended the 34th Ontario Industrial Waste Conference at the Prince Hotel in Toronto, June 14 –17, 1987. Twenty-one original papers were presented covering the multiple disciplines of environmental management of interest to delegates from industry, the federal and provincial governments, and academic institutions. The adept handling of sessions by the five moderators resulted in an excellent exchange between the audience and the authors.

As Chairman of the 34th Conference, I extend my thanks to all the authors, the session moderators, the delegates, and the Planning and Program Committee members, all of whom contributed to the success of this, the first Industrial Waste Conference under the auspices of the Ministry's Waste Management Branch. As in past years, we strived to maintain the high standard set by previous Conferences in the discussion and deliberation of the various aspects of the treatment and disposal of industry's gaseous, water, and liquid/solid wastes. Consensus was that this objective was achieved.

Regretfully, because of new responsibilities within the Ontario Government, this will be my first and last tenure as Chairman. My involvement in the Conference for the past four years as a member of the Planning Committee has been most rewarding and satisfying. I wish continued success to my successor, and hopefully will have the opportunity to attend future Conferences as one of the delegates.

On behalf of Environment Ontario, thank you for registering for the 34th Conference. The subsequent Proceedings provide you with a permanent record of the papers presented. The 35th Conference is booked for June 12 – 15, 1988, at The Prince Hotel in Toronto. You and your associates are invited. Schedule the dates now and plan to attend.

R.M. Gotts,
Chairman

ONTARIO INDUSTRIAL WASTE CONFERENCE
HISTORICAL DATA

Location	Dates	Sponsor
Ontario Agriculture College, Guelph	1954 to 1956	Pollution Control Board of Ontario
Delawana Inn, Honey Harbour	1957 to 1963	Ontario Water Resources Commission, Water & Pollution Advisory Committee
Bigwin Inn, Lake of Bays	1964 & 1965	Ontario Water Resources Commission, Water & Pollution Advisory Committee
Park Motor Hotel, Niagara Falls	1966 & 1967	Ontario Water Resources Commission
Sheraton Brock Hotel, Niagara Falls	1968 to 1971	Ontario Water Resources Commission
Skyline Hotel, Toronto	1972 to 1974	Ontario Ministry of the Environment
The Prince Hotel, Toronto	1975 to 1987	Ontario Ministry of the Environment

Conference Chairman	Dates	Secretary/ Co-Ordinator
Dr. A.E. Berry	1954 to 1962	D.S. Caverly/M. Grove
D.S. Caverly	1963 to 1973	L.M. Tobias
K.H. Sharpe	1974 to 1976	M.J. Cathcart (1974)
D.P. Caplice	1977 & 1978	
	1975 to 1987	M.F. Cheetham
J.W. Giles	1979 to 1986	
R.M. Gotts	1987	

Program Conveners

1954-1959	A.V. DeLaporte
1960-1973	F.A. Voege
1974-1978	J.B. Patterson
1979-1987	R.C. Stewart

CONFERENCE PLANNING COMMITTEE

Conference Chairman
R.M. Gotts,
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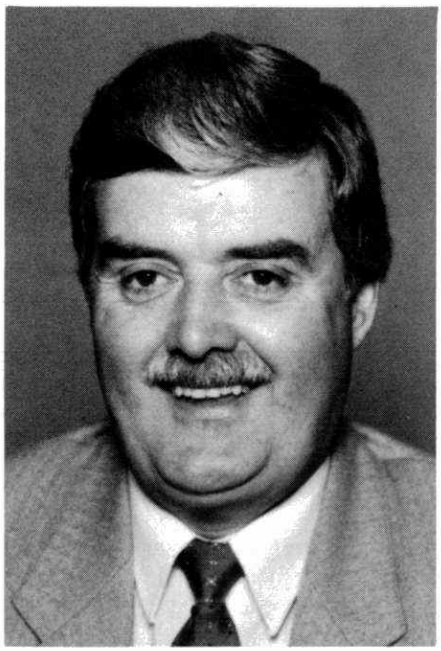
Waste Management Branch,
Ontario Ministry of the
Environment



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Northeastern Region,
Ontario Ministry of the
Environment

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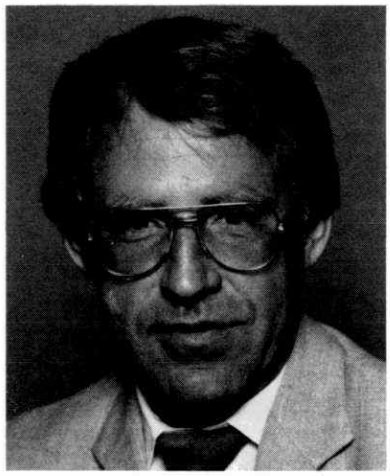
TECHNICAL PROGRAM COMMITTEE



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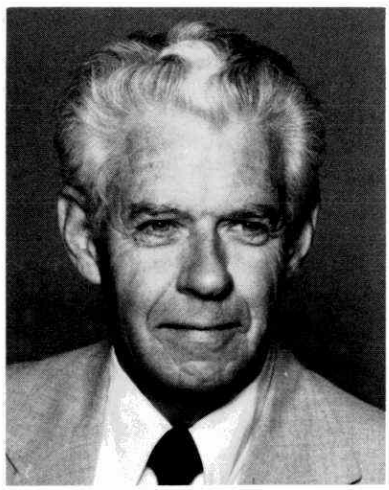

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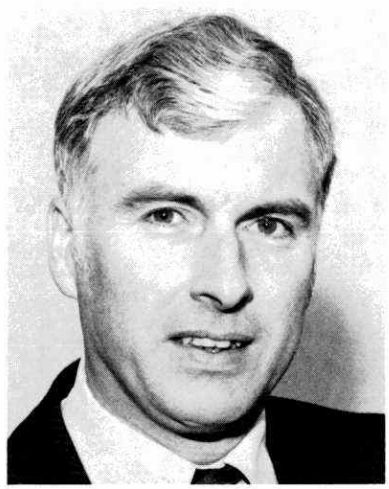

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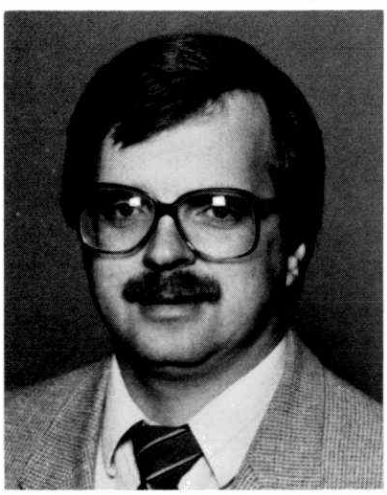

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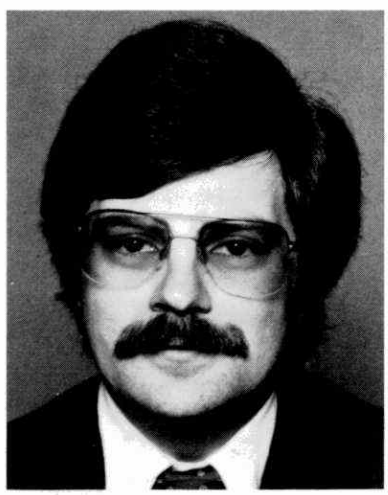

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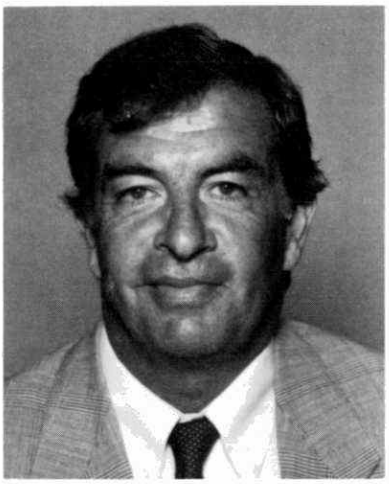
THE PAPERS AND THE AUTHORS

at the

34th ONTARIO INDUSTRIAL WASTE CONFERENCE

JUNE 1987

TORONTO, ONTARIO



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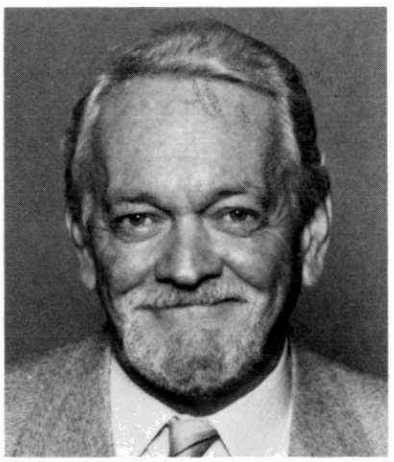

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Intergovernmental Relations
and Strategic Projects Division,
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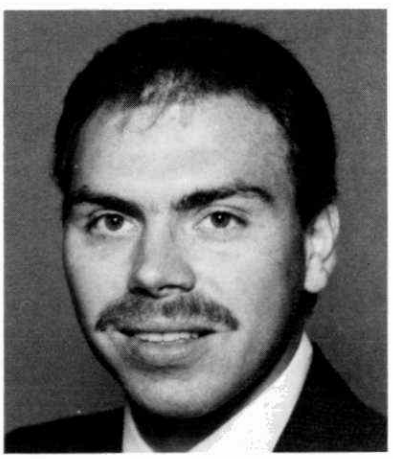
R.V. Griffiths,
Project Manager,
OWMC, Toronto



J.W. Reed, Technical Analyst,
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Don Mills, Ontario

PROGRESS REPORT ON ONTARIO'S ENVIRONMENTAL PROGRAMS

by

The Honourable Jim Bradley,
Ontario Minister of the
Environment, Toronto

I am pleased to come before you today to speak about my ministry's efforts to manage wastes in Ontario.

Ontario is blessed with great natural wealth. This blessing carries with it great responsibility to protect nature's life-support systems and to husband our resources.

From the moment we took office, our government has given a fresh impulse to environmental restoration and protection in Ontario. We have been working hard for nearly two years now to put in place policies and programs to turn the tide against environmental degradation. But no one knows better than I how much more we still need to do.

The 1983 Blueprint for Waste Management found that little progress had been made in the implementation of 4R Programs for Waste Management. These methods - reduction, reuse, recycling and recovery - were not being used effectively to divert large amounts of waste from less desirable options such as landfill.

The dialogue following the Blueprint had a common theme - that the implementation of the 4Rs, and the development of sound waste management practices, would need substantial provincial support.

With adequate provincial help, it was estimated that at least 30 per cent, and perhaps as much as 50 per cent, of Ontario's solid waste could be diverted from landfill within 10 years.

I am pleased to tell you today that my ministry's Comprehensive Funding Program for Waste Management will provide the kind of funding - starting this year - that municipalities need to do a better job managing garbage. This program, whose true financial dimensions will take several years to develop, will provide the kind of provincial support for waste management that sewer and water projects receive.

The Comprehensive Funding Program for the 4Rs, and for waste treatment and disposal, includes both new and enhanced support for municipalities and industry. These are long-term commitments to support better environmental practices.

We will provide resources to ensure that municipalities are able to establish state-of-the-art waste treatment and disposal facilities.

We will help municipalities apply remedial measures to existing problem landfills.

We will promote environmentally sound long-term waste management planning in Ontario.

My ministry's landfill inventory indicates that up to 300 municipalities will require additional landfill capacity within the next ten years. Over 150 municipalities are currently involved in preparing 28 Waste Management Master Plans.

Here is what my ministry will be doing for the 4Rs.

Our funding for municipal recycling continues to increase. When we came into office, only $750,000 a year had been allotted to support municipal multi-material curbside recycling programs.

I increased the budget to $2 million last year, then found that even that amount was not enough to meet the demand for good municipal recycling programs. So we reallocated money within the ministry to help municipalities recycle garbage instead of landfilling it.

This year, we have budgeted nearly double last year's estimate, and again I stand ready to reallocate whatever funds are needed by municipalities to implement and operate recycling programs.

To complement this recycling effort, I am pleased to announce today a new Municipal Material Recovery Program.

This new program provides capital grants for municipalities, singly or in groups, proposing to recover material from municipal wastes. Private sector proposals may be considered through municipalities.

Eligible projects include facilities to recover or process papers, refuse or waste-derived fuel, compost, aluminum, steel, glass, plastic or other materials from mixed solid waste. The grant may be applied to a feasibility study, design, approval, construction and commissioning of a proposal.

The maximum assistance for capital facilities is 33.3 per cent of the in-service capital cost. For research, development and demonstration projects, we will provide up to 100 per cent for a defined period.

I am also pleased to announce a new Municipal Reduction and Reuse Program.

We will support municipal initiatives to achieve reduction or reuse of municipal waste by making consumers and producers of consumer products aware of the need to reduce waste. The purpose of this program is to influence consumers to alter their buying habits, and to persuade producers to offer less wasteful types of goods and packaging.

We will provide grants of up to 50 per cent of promotional or capital costs, while creative materials may receive up to 100 per cent of costs, with a limit of $25,000 for a single project. Municipalities, individuals and companies are eligible.

We are also increasing funds available for the Market Development Program.

Expanding the Market Development Program is necessary to keep pace with the projected increasing amount of waste recovery resulting from recycling programs.

Now let me turn to the second component of the Comprehensive Funding Program.

For years, municipalities have contended that existing provincial programs do not provide adequate assistance for the well thought-through, environmentally sound waste treatment and disposal facilities we now require.

I am pleased to announce today a new Financial Assistance Program to aid municipalities in establishing landfilling sites, transfer stations, and processing sites.

Eligible costs include: technical studies, engineering design, hearings and approvals, public consultation, and capital costs for land acquisition, construction, and equipment, retrofitting and expansion.

The following levels of assistance are available:

Small municipalities serving a population of 7,500 or less are eligible for assistance totalling 75% of these costs. Groups of municipalities are eligible for 60% assistance. Regional municipalities and individual municipalities serving a population exceeding 7,500 are eligible for 50% provincial assistance under this new program.

Many existing disposal facilities need upgrading. Proper planning for waste management facilities, including public participation, is essential to minimize environmental problems later.

To address these needs, we are expanding our Waste Management Improvement Program.

This program currently provides up to 100 per cent of the total cost to municipalities for upgrading, closure and remedial measures for active landfills.

In the past, the budget for this program has been insufficient to meet demand, a situation we are rectifying.

We are also increasing funding for the Waste Management Master Plan Program.

This program provides up to 50 per cent of the cost to municipalities for long term comprehensive planning studies for waste management.

Budgets for the program have fallen behind demand. A budget increase of 50 per cent was approved for 1987-88.

The third aspect of our Comprehensive Funding Program is substantial financial aid to industry. We expect that the Industrial Four Rs program will result in a significant diversion of industrial wastes from landfill through process changes or improvements, waste treatment and an enhanced waste exchange.

I have seen how positively business can respond to environmental problems. The soft drink industry has created OMMRI - Ontario Multi-Materials Recycling Incorporated - and through it has directed $20 million to support municipal recycling programs. I commend the industry for its creative approach to a waste problem.

An initiative my ministry has already acted upon is the financial support of the Ontario Waste Exchange. This support will enable the Exchange to become an active, rather than passive, exchange which should result in increased quantities of waste being diverted from landfills.

But now we are also offering financial and technical assistance to industry to help it usher in a new age of efficient waste management.

The goal of the new program is to foster development of new technology.

Such development is often risky. Especially in a relatively undeveloped field, such as waste management.

All too often when industry comes up with a proposed process which it thinks will be beneficial, the good idea gets nipped in the bud because of the costs and risks involved.

If you submit a proposal to us that shows us that your idea is an improvement on existing equipment or processes which will reduce waste, we will help you with your demonstration or evaluation of the technology or process.

All commercial and industrial sectors may apply, as can consulting firms engaged in industrial 4R work, whether or not the application is on behalf of a specific industry.

If we feel that a proposal is solid, we will provide assistance in the form of money, technical expertise, and information, or all of these. The level of support a project will receive will be decided on a case-by-case basis.

I invite both industry and municipalities to take advantage of the new programs and the enhanced provincial support for environmentally sound waste management which I have outlined today.

We have budgeted eight-point-five million dollars this year for these programs. If municipalities and industry make good proposals requiring more provincial funds this year, I will find the necessary money.

The management of wastes is one of the biggest, if least glamorous, challenges facing us as we approach the 1990s. The new and enhanced programs I have announced today put substantial resources in the hands of the front-line players who are grappling with these sometimes difficult situations.

Our government stands with you in meeting this challenge.

Thank you.

CANADIAN COUNCIL OF RESOURCE AND ENVIRONMENT MINISTERS AND ITS HAZARDOUS WASTE ACTION PLAN

by
J. Walter Giles, Associate Deputy Minister, Intergovernmental Relations and Strategic Projects Division, Ontario Ministry of the Environment, Toronto

Thank you Mr. Chairman, Mr. Minister, ladies and gentlemen. First let me extend Earle Anthony's regrets. Earle is Acting Deputy Minister of Environment for British Columbia where a re-assignment of Deputies has occurred and he could not be here today.

We have been asked to discuss the Canadian Council Resource and Environment Ministers' Action Plan for the Management of Hazardous Waste.

First a little history. The Canadian Council of Resource Ministers was formed in the early 1960s and the Environment Ministers were added to make it CCREM in the 1970s, as environment ministries sprang up across the country. Traditionally the Council has had eleven member governments each represented by its Resource and Environment Ministers. These have varied from province to province depending upon how their government business is organized. In recent years the Yukon and the Northwest Territories have joined the Council.

The presidency rotates among the governments and a Coordinating Committee of Deputy Ministers assists the Ministers to ensure the smooth working operation of the Council. There is also a small Secretariat that serves the needs of Council by arranging the meetings and providing secretariat services to all the meetings of Council and its committees. From the overhead (Fig. 1) you can see that there are four advisory committees which are made up of senior civil servants from the various governments. These are: Air, Water, Toxic Substances and Waste Management, and Research.

As a long time participant in the activities of the Council I can report that in terms of its programs and vitality it has had a variable history. At the present time it is probably in one of its most dynamic and active phases and we now see the development of national programs and policies and the addressing of some very serious problems confronting Environment Ministers across the country. During the 1980s the environment component of the Council emerged as primary in terms of the issues addressed, and with the recent formation of the Canadian Council of Forest Ministers the issues of interest to Environment Ministers dominate the programs. There are common interests such as pesticides, herbicides and environmental assessment.

Incidentally, the gentlemen sharing the podium with me today are a significant reason for the current vigour of CCREM. Jim Bradley as Minister, Rod McLeod as Deputy Minister on the Coordinating Committee and Ron Gotts, Waste Management Advisory Committee have all provided good leadership in developing programs.

One concern expressed in recent meetings was the registration process for pesticides (Fig. 2 illustrates).

The federal review by the Departments of Health and Welfare, Environment and Fisheries and Oceans leads to a risk/benefit analysis with Agriculture evaluating the benefit part of the equation. The final decision on import and sale is made by the Federal Ministry of Agriculture. The provinces then must schedule the type of use, which in Ontario ranges from application only by licensed applicators for specific uses to use by anyone, eg. homeowners use of herbicides and insecticides.

A recent meeting of the Provincial Environment Ministers with the Federal Health and Welfare, Agriculture and Environment Ministers led to the possibility of resolving some problems, such as access to information by provinces and temporary registration, where inadequate risk data is available.

Another federal/provincial initiative with promise is in standard setting. In this situation we depend on Health and Welfare expertise, and the Environment Ministers share responsibility with Health Ministers in setting standards.

This diagram (Fig. 3) illustrates how we hope to improve liaison and increase effectiveness. We have two parallel streams of activity and even though we had some Environment Assistant Deputy Ministers on both committees, cooperation and coordination was not always good enough to meet our needs.

The solution adopted is a Joint Assistant Deputy Minister Committee Co-Chaired by the Environment Canada Assistant Deputy Minister of Conservation and Protection, Lorette Goulet and the Health and Welfare Assistant Deputy Minister Bert Liston to coordinate the activity of the Multimedia Guidelines and Standards Advisory Committee, the Toxic Stustances Committee of CCREM and the Advisory Committee of Environmental and Occupational Health. The Assistant Deputy Minister Committee will set priorities and be the Committee to which the Multi-Media Standards Committee reports.

I leave it to you to re-read the excellent presentation at last year's Conference by Bev Thorpe, Brendan Birmingham and Ivy Wile on how Multimedia Standards are set (pg. 37 in the proceedings).

Now to the assigned topic. The Action Plan for the Management of Hazardous Waste has been prepared by the Waste Management Sub-Committee of the Toxic Substances Committee and appproved by the Deputy Ministers and the Council of Ministers. The plan was announced in March of 1987 by the President of the Council, the Honourable Clifford Lincoln. It is intended to develop an adequate and consistant application of legislation and programs across the country and to encourage the development of proper disposal facilities.

Because the management of hazardous wastes has national implications, a cooperative and concerted effort by all sectors of society including the various levels of government, industry and the public is required. In the Action Plan approved by the Ministers these facts are recognized and work is underway to meet the need. The approved plan is intended to promote cooperative efforts and reduce potential overlaps in areas such as research. It is also designed to harmonize hazardous waste legislation and programs both within Canada and internationally.

It is intended to foster a more cooperative approach in the establishment and use of centralized waste management and disposal facilities. And finally it is intended to improve the public's understanding of their role in this important issue.

The Council through its committee and with the assistance of a consultant, Peter Budzik, will be following the progress of the plan through to its completion. Out of this effort will come the following benefits to all Canadians:

1. A framework to ensure that the management of hazardous wastes across Canada is brought under control and that realistic public expectations can be fulfilled.

2. The increased implementation of hazardous waste reduction and recycling initiatives by industry.

3. The development and implementation by all jurisdictions of a uniform national definition of hazardous waste and standards for future revisions of the hazardous waste list.

4. A cooperative interjurisdictional approach towards the establishment and use of centralized hazardous waste management facilities.

5. The development and adoption of national codes of good practice for waste management.

6. A program to address active and closed hazardous waste sites, including a study of the feasibility of establishing a national contingency fund.

7. And the enhancement of the public's understanding of the issue and the problems involved.

Let me take you quickly through the plan and indicate where we stand.

DEFINITIONS

The first task is to establish a standardized national definition of hazardous waste to cover both transportation and waste management needs. There are six projects under this action item:

o First is a regulatory review of the hazardous waste definition which is well along and the results expected by the end of the year.

o Second project is the criteria for defining and listing hazardous waste. Again work is underway but it will take until '89 before this is completed.

o Third is testing protocols. These are underway but again the results are not expected until '89.

o Fourth, is the uniform numbering identification system for waste. This must mesh with the Transportation of Dangerous Goods legislation numbering system.

o Fifth, the mechanism for updating the list and the hazardous waste criteria. This will follow the earlier projects.

o Sixth, amendments to the Transportation of Dangerous Goods Act and the regulations and the provincial legislation to ensure uniformity.

GUIDELINES

The second action item is to establish national guidelines for a range of hazardous waste management facilities to ensure the protection of the national environment and the public health in Canada. The activities include:

o First, the development of three national guidelines. Those for incineration and guidelines for physical and chemical treatment. These are both well along and expected to be completed this fall. The national guidelines for landfill operations have been reviewed and we expect them to be completed by mid-summer.

o The second project is establishment of codes of practice for industrial sectors and waste types and these will follow completion of the first project.

o The third project is a mobile waste mangement regulatory review for all provinces. In this case a consultant will be hired and we expect the report to be completed by early 1988.

o Fourth, is a mechanism for collective management of hazardous waste from small generators. This project will not begin until next year.

ROLES AND RESPONSIBILITIES

The third action item deals with regulatory responsibilities of generators, carriers and receivers. It is intended to establish a uniformity in addressing the roles and responsibilities of hazardous waste generators, transporters, recycling treatment and disposal operators.

The purpose is to develop a uniform approach across the country and prevent the creation of pollution havens. It will also deal with the transboundary movement of waste.

o The first project is a review of the federal and provincial regulatory controls and this report is expected by late summer. The contract has been awarded to MacLaren Plansearch.

o The second project is to establish uniform responsibility for hazardous waste generators, haulers and receivers. This will follow the completion of the first.

DECOMMISSIONING

The fourth action is to deal with decommissioning and will establish uniform approaches on decommissioning industrial plants, storage facilities and waste disposal sites. The projects under this action are:

o First, the action level criteria for site clean-up and here there is a review of international criteria underway.

o Second, is national guidelines for decommissioning industrial sites.

o Third, is national guidelines for remedial action, where public health or environment is threatened. This is well underway.

o The fourth is a uniform implementation strategy for site decommissioning and this will follow the preceding three.

WASTE MANAGEMENT CONTROLS

The fifth action is to develop international and national harmonization of hazardous waste programs and controls. It recognizes that the sharing of hazardous waste management facilities may be more cost effective and environmentally superior in the handling of certain wastes. There are seven projects under this activity:

o First, is waste definitions and we are now reviewing the international definitions developed by the OECD.

o Second, is to develop a uniform and international manifest. Again international negotiations are underway.

o Third, is the international prenotification protocols and these should be achieved through OECD by December 1987.

o Fourth, is international agreements on transboundary movement of hazardous waste. Negotiations are underway.

o Fifth, is a federal/provincial review of practices concerning interprovincial shipments of hazardous waste. This will not be undertaken until there are more hazardous waste facilities established across the country.

o The sixth project is to recommend approaches to promote transboundary movement of hazardous waste for treatment and disposal. This will be deferred until further development of waste facilities occurs.

o The final or seventh, is the distribution of short and long term costs of hazardous waste regional storage treatment and disposal. Again it is deferred until more sites are developed.

CONTAMINATED SITES

The sixth activity is a program to address sites contaminated by hazardous materials. This involves a national program of remedial action at contaminated sites posing a threat to public health or the environment. Three projects are involved here:

o First, the inventory of hazardous material contaminated sites. Work is underway and a report is expected by the end of the calendar year.

o Second, is a feasibility study concerning the establishment of a national clean-up contingency fund. A draft report is expected very soon on this.

o Third, is development of a remedial action program for contaminanted sites. This will follow the first two projects.

THE FOUR R's

The seventh action involves the four Rs. It is to identify and develop mechanisms to maximize the reduction, re-use, recycling and recovery of hazardous wastes. There are four projects involved:

o First, to identify any barriers to the four Rs and recommend how these can be handled. This has been contracted to an outside consultant and we expect the report late this fall.

o Second, is a review of the waste exchange programs, both nationally and internationally. Report expected fall of 1987.

o Third, is a series of technical manuals regarding the application of the four Rs to specific wastes and this will follow the second item.

o Fourth, is to examine the employment enchancement opportunities in hazardous waste reduction. This project will be undertaken in 1988.

INFORMATION EXCHANGE

The last or eighth action relates to information exchange and public communication. "Improve and expand data and information on the quantities, types, management options and potential effects of hazardous wastes generated in Canada. Develop strategies to improve public understanding of the management of hazardous waste. Make available to public on continuing basis credible information on hazardous waste management (sources, risks, control measures)." It contains five projects:

o First, evaluation of the approach to hazardous waste data base establishment and maintenance. A report is imminent.

o Second, to identify the research needs and activities necessary in the management of hazardous waste. This is an ongoing project.

o Third, to develop an inventory and set priority of hazardous waste issues for an information program.

o Fourth, an information bulletin for specific issues and audiences. This would follow the completion of the third item.

o Fifth, development of specific awareness programs using appropriate communications media. This will follow the others.

From the foregoing outline of the Action Plan for the Management of Hazardous Waste, it is obvious a lot of good work is underway. It is both a shared work and a shared cost program. Many governments assumed lead roles in the various Action Programs and Projects. In addition, an assessment was made on all Governments to fund consultants and printing costs.

The fruits of these labours will be seen in two or three years when we will have much improved and more effective management of wastes right across Canada.

Mr. Chairman - that concludes my remarks as the Committee member substituting for Earle Anthony, Chairman of the Toxic Substances Advisory Committee of CCREM - and he is a very effective Chairman. Plaudits also go to Ron Gotts and the Waste Management Committee who really did much of the work on the Action Plan.

If there are questions, I'm sure we can find answers among us; Ron Gotts, Rod McLeod of the Coordinating Committee of CCREM and myself. Are there questions or comments?

Figure 1

CANADIAN COUNCIL OF RESOURCE AND ENVIRONMENT MINISTERS

ENVIRONMENT SECTOR

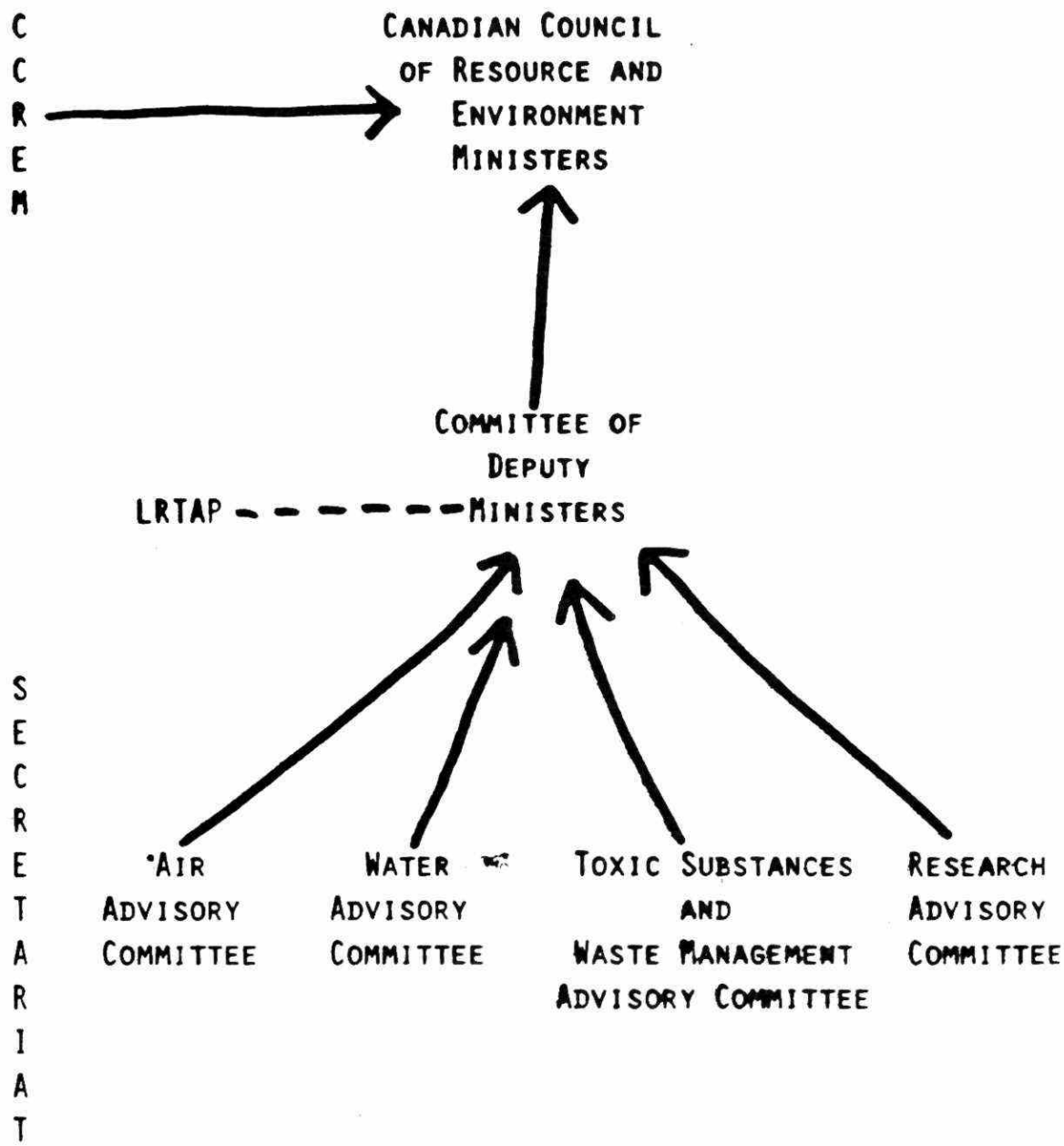


Figure 2

PESTICIDE APPROVAL PROCESS IN CANADA

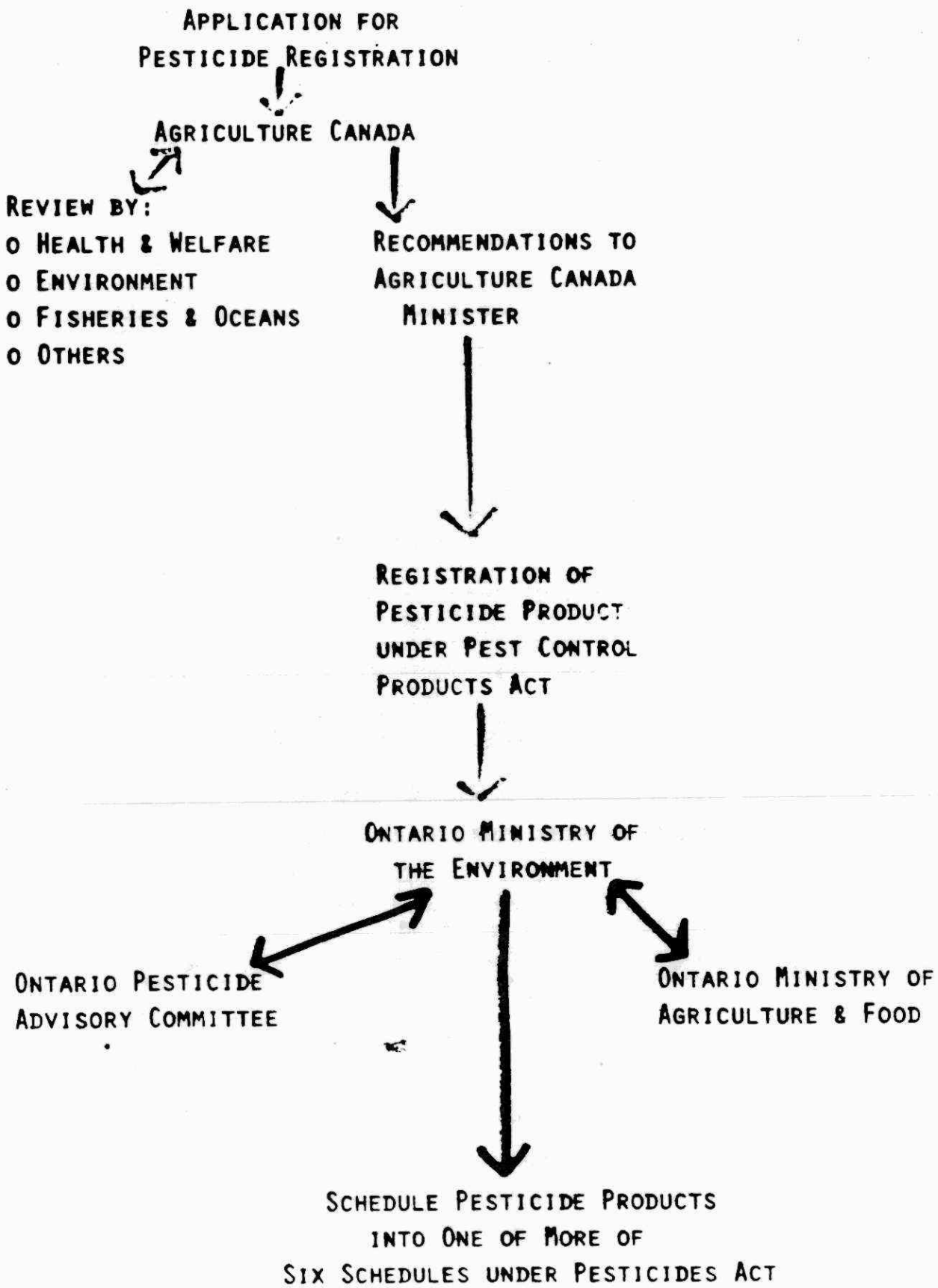
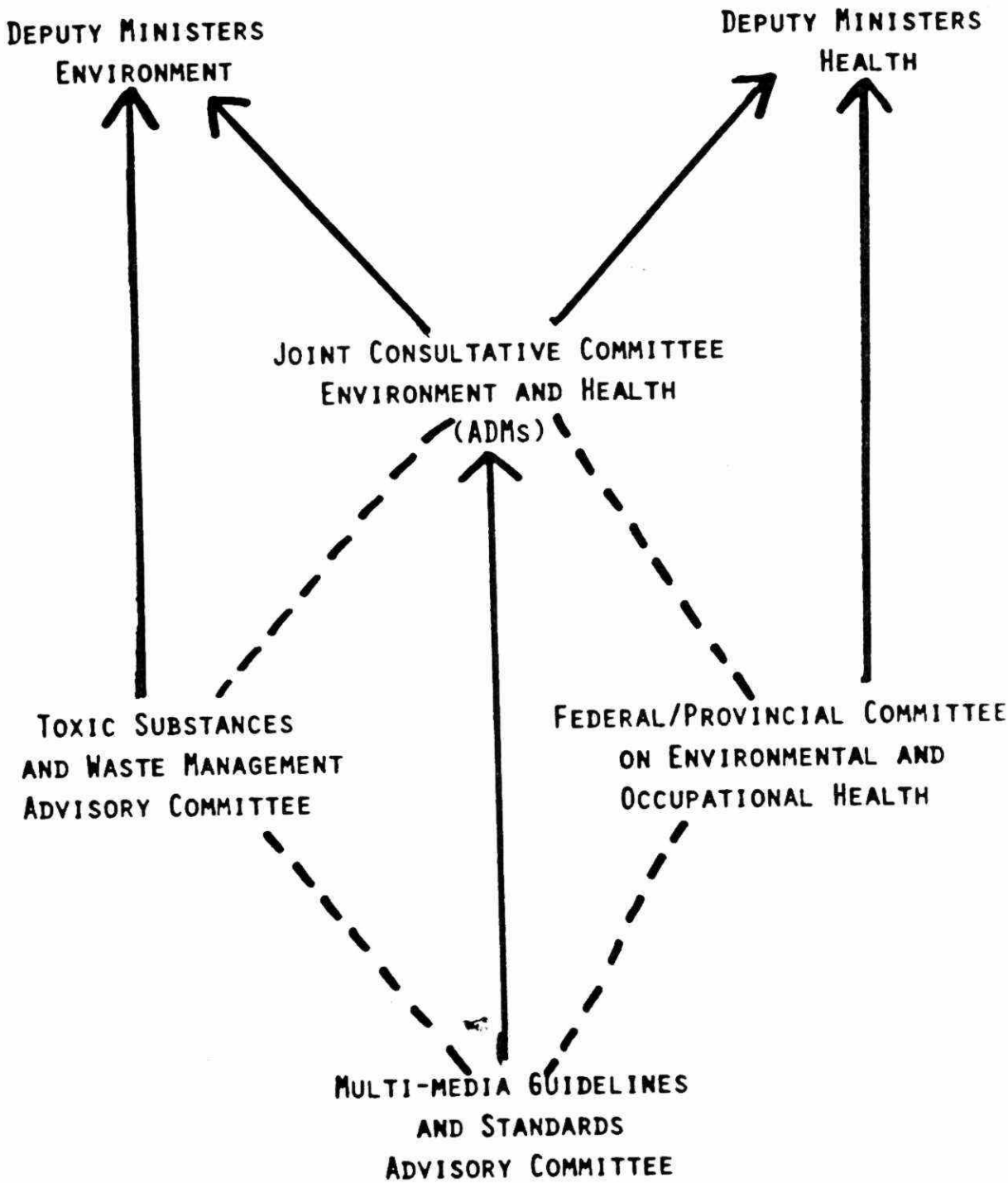


Figure 3

ENVIRONMENT/HEALTH JOINT INTERESTS



STATUS AND UPDATE ON THE ONTARIO WASTE MANAGEMENT CORPORATION

by
Dr. D.A. Chant, Chairman and
President, OWMC, Toronto

Dr. Chant, and his associates, E.H. Schmidt, Manager, Project Engineering, and R.V. Griffiths, Project Manager, spoke from notes and did not submit a prepared text for inclusion in the Conference Proceedings.

Should information on the status of the Corporation be desired, it is recommended that the agency be contacted direct at 2 Bloor St. West, 11th Floor, Toronto, Ont. M4W 3E2 - Telephone (416) 934 - 2918.

ENVIRONMENTAL AUDITING
CANADIAN PRIVATE SECTOR PRACTICES

by

John W. Reed, Technical Analyst,
Environmental Affairs, Texaco Canada
Don Mills, Ontario

INTRODUCTION

Few issues today hold greater consequence for corporate credibility than those related to the environment. As part of their overall approach to environmental protection, many firms are now applying a management practice known as environmental auditing.

Environmental auditing is an important topic because it has the potential to make a significant contribution to environmental protection. Its also an exciting topic because the field is growing quickly as more and more firms adopt programs.

Most people have at least heard the term environmental auditing before. It is used in the private and public sectors alike. However there is not a shared perception of what exactly environmental auditing is. The objective of this paper is to provide an overview of environmental auditing from a private sector perspective. This understanding is important since environmental auditing is sure to become the subject of increasing industry and government activity.

Topics to be covered in this paper include:

- Description of Environmental Auditing
- Characteristics of EA programs
- Benefits of EA programs
- Potential role of government
- PACE Activity

DESCRIPTION OF ENVIRONMENTAL AUDITING

Simply stated, environmental auditing is a process for self-evaluation of environmental performance. Such programs:

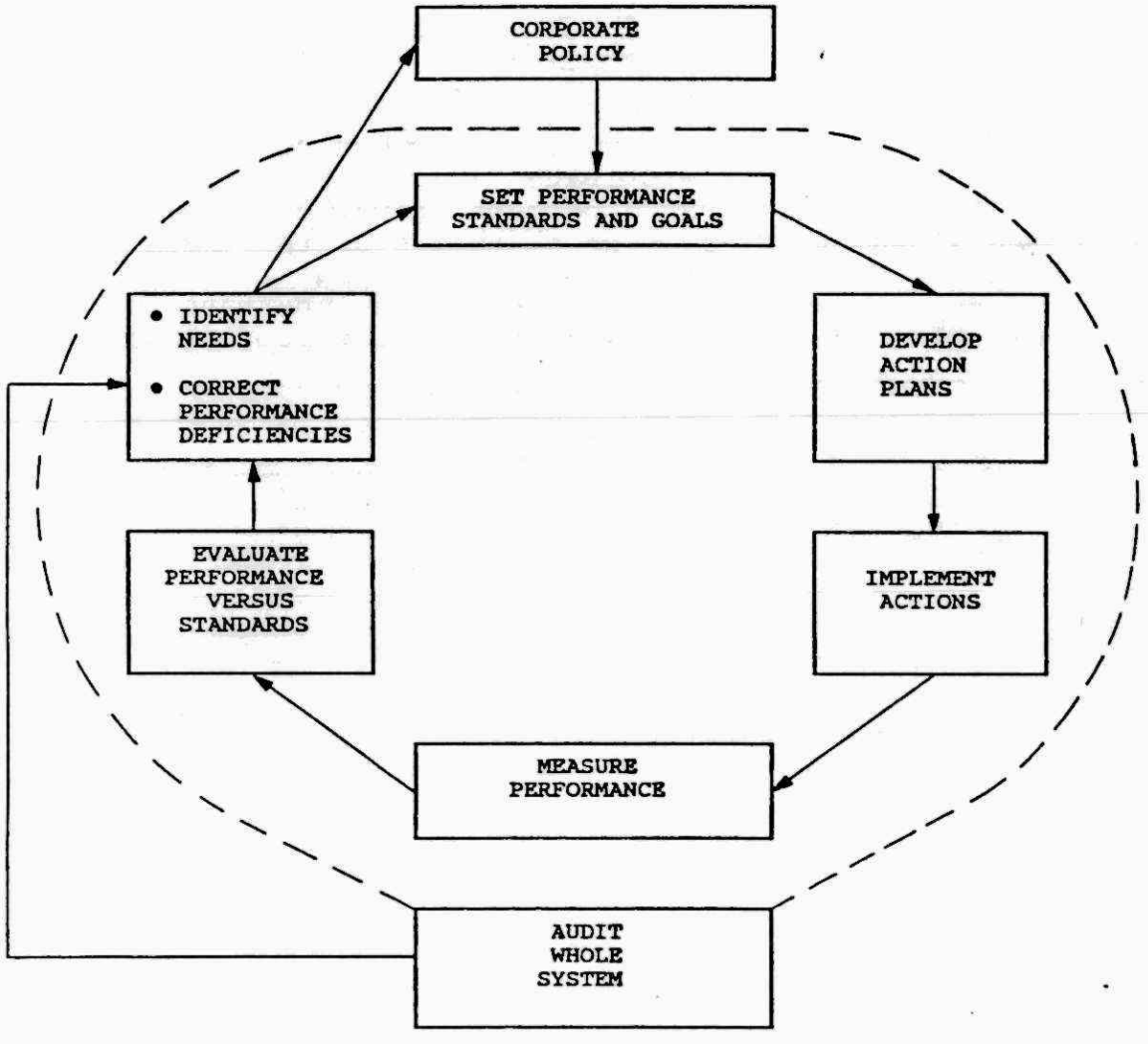
- are internally driven
- are voluntary
- have a formal structure and organizational status
- use rigorous and systematic procedures
- are conducted on a regular cycle, and
- are close-looped.

Environmental Auditing is like any other type of internal auditing. As such, it is a management tool used to monitor performance and detect where problems might arise. Any organization with more than two layers must in some shape or form monitor itself.

Figure One illustrates the function of environmental auditing graphically. It shows a general management process that might be used at a large facility of a major corporation.

FIGURE - 1

MANAGEMENT CYCLE



As Figure One shows, an environmental auditing is an evaluation of the entire environmental management activity -- each step in the generalized cycle. It is important to note that auditing is not just concerned with end-point performance. Instead, it has the ability to look at the whole spectrum of management activities that lead to or create that end-point performance.

In this respect, environmental auditing is like other types of internal auditing. Consider internal financial auditing: Internal financial audits aren't concerned only with balance sheets and cash flow -- they look at the whole set of practices that lead to sound financial management. Consider internal safety audits: Safety audits aren't concerned only with accident frequency rates and loss time injury rates -- they look at the whole set of systems that create and maintain safe working conditions. And so it is with environmental audits. Same idea; different topic.

It is also important to note that environmental auditing is the check on the system. It is not the system itself. An audit is simply a diagnostic tool. An audit only has value when there is something to diagnose. Too many people fall into the trap of believing that an audit is a panacea, a cure-all, a program that will somehow magically improve environmental management. That is patently false: An audit is just the check; The systems must be present in the first place.

There are three other points to raise in relation to this model.

First, the golden rule for environmental auditors is that they must be independent from the activities that are being audited. If they are not, objectivity and credibility are jeopardized. Normally, this means the audit is conducted by individuals external to the audited facility, such as Head Office personnel, Division personnel or even external consultants.

This doesn't mean that plant personnel can have no role in the audit program as a whole. On the contrary, some of the strongest programs maximize the participation of plant personnel. Such participation takes several forms, including:

- on site liaison
- assistance in designing the program
- participation in decisions regarding audit timing and scheduling.
- and, auditors of other facilities in the company.

Second, a commitment to follow up on audit results is an intrinsic part of any audit program. Follow up refers to actions taken by the company to respond to the findings of the audit in a reasonable fashion and in a reasonable timetable. Sometimes followup procedures are formal, sometimes followup procedures are informal.

Third, an audit is simply one of many, many tools that are available to today's environmental managers. For some companies, it is a good one. But it isn't right for every company. Indeed, it is not needed for every company: Environmental management systems can still be effective without an audit program.

PROGRAM CHARACTERISTICS

Before describing the characteristics of auditing programs, it is useful to understand what an environmental audit program looks like. A sample audit program might involve the following.

- The corporate environmental department is often given the mandate to conduct audits.
- They assemble a team of experts from within the company (2-6 individuals)
- This team visits the company's major facilities on a regular cycle, for example, every two years.
- The team will spend up to a week on site going over the plant with a fine toothed comb using a set of prepared guides.
- Afterwards, a written report is prepared and distributed to identified people within the company.
- The plant takes corrective action in response to the audit.

Notwithstanding the contents of this "sample" audit program, it is critical to understand that there is a substantial amount of variation among corporate environmental auditing programs. Environmental audit programs are generally tailor-fit to suit the specific needs, resources and culture of the individual firm. Just as each firm is unique, so too is each auditing program.

A number of different characteristics are helpful in describing environmental auditing programs. These include:

- objectives
- scope
- techniques
- program organization
- reporting
- protection of audit information
- follow up, etc.

This paper will focus on the first three only.

Objectives

The 1984 survey illustrated that companies institute environmental audit programs for a variety of reasons. In fact, some 20 different program objectives were identified. These ranged from

- verifying compliance with regulations, to
- avoiding fines and damage claims, to
- eliminating surprises, to
- enhancing employee awareness to
- improving cost control

Despite this variety of objectives, audit programs tend to have one principal driving force. This driving force is the major determinant of the overall shape of the program. It will affect:

- how it is staffed and resourced,
- what techniques are used,
- which facilities are audited,
- who the findings are reported to, etc.

Audit programs tend to fall into one of two categories. In some audit programs, the principle driving force is to provide assurance to company management that the environmental affairs of the company are being managed appropriately AND that the firm is in compliance with regulations. This is the "comfort factor". Such programs have a heavy emphasis on verification of compliance. The principle client is often the Senior management in the corporation. Some people describe these as "police audits", implying "an over the shoulder", "big brother" kind of approach.

At the other end of the spectrum, we find environmental audits that are primarily intended to provide assistance to line managers. In this mode, the audit is a service to help them improve their management system; in effect, the audit acts as a pair of "fresh eyes" for the facility. Here, the approach is more cooperative, less confrontational. We find a heavy emphasis on assessing the adequacy and effectiveness of environmental protection activities, as opposed to verifying compliance with standards.

In point of fact, most programs tend to blend aspects of both of these approaches. Rarely do they pursue one to the exclusion of the other.

Scope

Auditing programs also vary tremendously in their scope. There are at least two ways of looking at scope: by subject matter and by function.

Typical audit subject matters include:

- air management
- water management
- waste management
- emergency response and spill control
- hazardous materials
- process units
- health
- external relations, and others.

Some auditing programs are "comprehensive" in their treatment of subject matter. In other words, they look at a full slate of subject matters such as those listed above. Other programs are more "singular" in their approach, looking at only one or two subjects from the full slate. The singular approach allows for a more in-depth analysis of a given subject matter, all other things being equal, whereas the comprehensive approach gives a much wider perspective on plant performance. Both approaches are valid, and both are used by Canadian firms.

Another way of looking at scope is by function. For example, within each specific subject matter, there are a number of parameters to be examined. These include:

- permits and regulatory requirements
- company policies
- operating practices
- management systems
- monitoring and record keeping practices
- training programs
- employee awareness
- equipment maintenance, and others

Some auditing programs choose to focus only on regulatory requirements for each subject matter reviewed. (Some people call these "compliance audits".) Other programs put an emphasis on the management systems and controls that lead to compliance with regulations. (Some people call these "management audits".) Other programs still attempt to look at all aspects of environmental management, including the full list of functions. Virtually all audit programs start out as so-called compliance audits. However, as programs mature, the focus often shifts towards the management systems which underly compliance.

By combining subject matter and function, it is easy to see that audit programs have a vast range of potential scope, from the

- single subject, single function, to a
- multi-subject, multi-function

Techniques

Audit programs also vary substantially in the techniques they employ. Essentially, environmental auditing is a process for gathering information. Auditors generally gather information using a blend of three ways:

- they look at what goes on - Observation
- they ask a lot of questions - Inquiry
- and, they conduct tests - Testing

Audits that are assessment oriented tend to make different use of these techniques than do audits that are verification oriented. Assessment oriented audits emphasize observation and inquiry skills. Observation and inquiry in turn, rely heavily on the professional judgement and communication skills of the auditors. In contrast, verification tends to emphasize testing against known standards or criteria. Testing in turn puts a heavy emphasis on the auditing skills of the auditors.

As for specific tools, auditors carry out their business in a number of ways. For example, they:

- use checklists and questionnaires
- use formal protocols or manuals
- watch people as they work
- conduct interviews with employees
- physically inspect units and facilities
- take photographs
- search through records and files, and, in some cases
- send samples to external labs.

There are many other characteristics to describe auditing programs. But the point is that there is a tremendous variety to this program labelled environmental auditing. The characteristics of programs are unique to each company having been designed to meet the specific management needs, resources, and culture of the implementing firm.

BENEFITS OF AUDITING

The 1984 survey indicated that a full 25% of the respondents were conducting auditing programs. The number of firms conducting environmental auditing programs has increased since then. The simple fact is this: Canadian firms are adopting environmental auditing programs on their own. Obviously, there must be some benefits to the process. The benefits of auditing programs generally derive from the product -- i.e. the results -- as well as from the process used to arrive at the product.

The chief benefits include -

1. Measurement of achievement and progress in environmental protection. As an on-going monitoring tool, audits provide a benchmark against which environmental programs can be measured.

2. Substantiated data on compliance with external requirements, company policies and good management practices. A solid data base is critical to effective decision-making; Audits provide a database that can be used by many management levels.

3. Protection against liabilities and proof of due diligence. Audits help to identify weaknesses in the systems that underly compliance. Audits also provide documentation of due diligence.

4. Identification of risk exposures and early warning of potential problems. As the saying goes - "An ounce of prevention is worth a pound of cure."

5. Improved communications between and within operating facilities. Audits lead to the sharing of information throughout an organization.

6. Education and training. The sheer visibility and process of audits speak volumes to line personnel.

Clearly, audits are instituted for sound business reasons. But there is an added plus. Audits can result in a better level of protection for the environment.

GOVERNMENT ROLE

Because audits are good for firms and for the environment, I believe the government, if anything, should adopt a supportive role for auditing. A supportive role can be garnered through:

- sponsoring conferences and workshops
- providing technical assistance to firms who want to learn about programs
- publicly endorse firms with programs
- and other activities that encourage the spread of voluntary auditing.

The 1984 study of Canadian industry identified a strong level of support for this type of government role.

I do not believe however, that the government should go as far as to require environmental auditing, whether that requirement is in the form of a regulation, a policy, or even an attitude. This is because the minute an audit is required, the nature of the beast is changed. It is no longer a voluntary program suited to the management needs of the firm, but a regulatory requirement. And all the innovation and commitment that is so characteristic of voluntary programs will be lost.

The U.S. EPA looked at requiring audits, and decided not to. As a regulatory agency, they felt they had neither the expertise to develop, nor the resources to maintain, a mandatory auditing program.

It is important for the Ministry of the Environment to develop and communicate a policy with respect to the treatment of existing audit programs. Developing such a policy is no simple task. For while the Ministry of the Environment must safeguard its mandate to protect the environment and ensure responsible corporate behaviour, it must also ensure that companies who have auditing programs are not accorded unfair treatment relative to companies who don't have programs. The fear for companies is that internal, voluntary audit programs might be used to trigger government actions or requirements that might not otherwise have occurred. A policy that allows firms with programs to be effectively penalized relative to those who don't, whether such "penalties" are intended or not, would have detrimental implications on the development and spread of voluntary auditing programs.

In developing this policy, I only hope two things happen.

- First, that industry and government work together

and second,

- that the Ministry of the Environment not repeat the mistakes of the U.S. EPA, by fumbling around for 7 years before finally arriving at a policy stand. The U.S. EPA actions caused a significant set back in the development of audits.

PACE ACTIVITIES

PACE is a national, non profit, technical organization composed of

- Esso
- Husky Oil
- Petro-Canada
- Petrosar
- Shell
- Suncor
- Texaco
- Ultramar

PACE is a leader in the area of environmental auditing, as well as many other environmental endeavours.

In 1984, PACE sponsored a workshop for its members to learn about auditing, and encourage the use of the practice.

More recently, PACE has been working with the federal government, and other industry associations, in developing educational materials on auditing

- one is a video tape
- the other is a planned National Conference

The most recent PACE project is the PACE EA Rating System. This project, when completed, will provide PACE members with industry accepted benchmarks against which they can assess their performance. The project will also allow PACE members to score performance such that progress can be measured on an on going basis.

CONCLUSION

Since its earliest application, the goals and functions of audit programs have expanded considerably. It is no longer restricted to measuring compliance and monitoring performance. It is used effectively as a tool for line management, education training and communication. As such, it has tremendous potential to make valuable contribution to protection of the environment.

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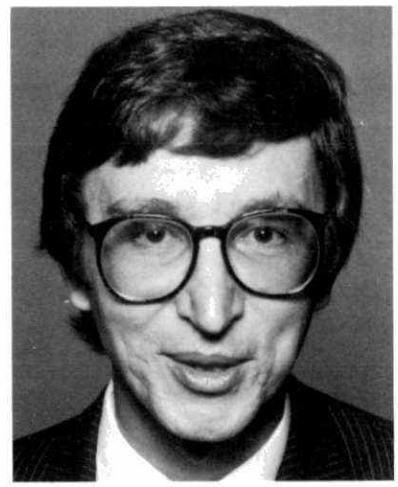

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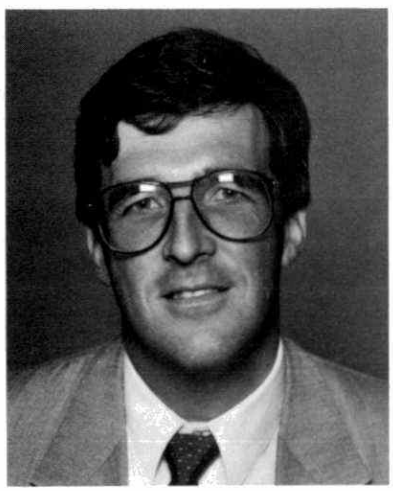

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INVENTORY OF COAL GASIFICATION PLANT WASTE SITES IN ONTARIO

by

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INTRODUCTION

During spring and summer 1986, buried hydrocarbon wastes were discovered in Ottawa and in Waterloo at sites which at one time were occupied by manufactured gas plants. Manufactured gas plants produced gas for illumination and heat in Ontario for over 100 years, from about 1840 to the late 1950s, by carbonization of coal or oil. Subsequent availability of electricity and natural gas caused many of the manufactured gas plants to be uneconomical and close down, some as early as 1890, many in the 1920s and 30s and almost all by the late 1950s. In addition to combustible gas, gas plants produced tars, sludges, liquors and other gas cleaning wastes, that contain chemicals hazardous to human health. Although many of these by-products were sold for refining and reuse, some by-products were often buried at plant sites both during plant operation and subsequent to plant demolition. The buried wastes encountered at these sites were exposed unexpectedly during excavation and were only associated with former manufactured gas plants after review of historical records.

In order to minimize future environmental impacts at as yet unidentified former manufactured gas plant sites, an inventory and preliminary assessment of manufactured gas plant sites in the Province of Ontario was undertaken. The information collected during this study will be of use to municipalities, landowners and developers and will likely form the basis for further investigations and possible remedial actions at individual sites.

The objectives of the study were threefold:

- establish a comprehensive inventory of manufactured gas plant sites in the Province of Ontario;
- assess the potential environmental impact of each identified waste site and;

- develop options for further actions which will more clearly define the chemical nature and physical extent of wastes and potential environmental impact at each site.

To meet these objectives, the study was completed in four phases; 1) a historical record search to identify former manufactured gas plant sites, 2) site reconnaissance visits to determine land use and evidence of buried wastes, 3) assessment of potential environmental impact considering site characteristics, evidence of buried wastes and resource characteristics, and 4) development of options for further actions at each site.

This paper describes the results of a study which provides an inventory and preliminary assessment of manufactured gas plant waste sites in the Province of Ontario. The study scope is restricted to waste sites that were associated with gas manufacturing for municipal illumination and heating, or so-called "town gas" facilities. Waste sites associated with industrial facilities that utilized coal carbonization for manufacturing of gas, coke, ammonia, and other products were not addressed in this study. These facilities include fertilizer plants, coke ovens, creosote plants and metal refining operations as well as large industrial users of manufactured gas. Many of these industrial sites remain in use today as controlled-access, industrial properties and therefore are likely of less concern than demolished and forgotten "town gas" waste sites. This study has also not considered secondary tar reprocessing and refining industries that utilized tars produced by the carbonization of coal and oil in the manufacturing of various oils, coatings and refined tar products. These facilities include roofing tar plants, creosote or wood preservative plants, and varnish and tar paper manufacturing facilities.

Before describing the methodology and results of this study, an overview of former gas plant operations and the chemical characteristics and environmental behaviour of gas plant wastes is appropriate and is provided below.

GAS PLANT OPERATION

Most of the gas plants in Ontario were operated until a more economical source of gas or hydroelectric power was available. In some communities in Southern Ontario, gas was available from natural gas fields and therefore city operated gas plants may have had short lives or were operated intermittently. Many communities also depended heavily on hydroelectric power and may not have required gas or may have received gas via pipelines from adjacent communities. By the early 1950s inexpensive natural gas, brought to Ontario by pipeline from western Canada, made most manufactured gas plants obsolete.

Many different types of gas generating processes were in operation in Ontario, and many gas plants used several different processes or changed the manufacturing process during the life of the plant. Essentially, the process consisted of heating coal whereby the gaseous (volatile) components of the coal are removed and collected. The different processes for generating gas result from the various methods used to separate the volatile components from the coal. Types of manufactured gas, each using a slightly different process, included:

- coal carbonization;
- blue gas;
- water gas; and
- producer gas.

An excellent review of manufactured gas processes and environmental aspects of gas plants is provided by Environmental Research and Technology Inc. (ERT) and Koppers Company Inc. (1984).

Coal carbonization involves the treatment of coal by heat at either low or high temperatures in the absence of air to drive off the volatile components from the coal. The resultant products are a fuel gas and coke. The carbonizing of coal can be achieved in gas retorts or coke ovens. Gas retorts are essentially large, semi-cylindrical, fire brick or silica ovens with the axis of the cylinder oriented either horizontally, inclined or vertically. The vertical retort was the most common and consisted of either an intermittent or a continuous method of recharging the coal. Figure 1 shows the material flow schematic for a typical retort gas plant.

Water gas or carburetted water gas (Figure 2) is produced by cracking oil in the presence of blue gas and steam. Blue gas is produced by passing steam over incandescent coke. The water gas method is therefore similar to that used for blue gas except that oil is added to the blue gas in a carburetor to form a blue gas/oil gas and steam mixture. The oil gas is then cracked (i.e., the oil is reduced to lower hydrocarbon gases) in a superheater and cleaned in a wash box to produce a gas of high heating value.

In Ontario, most of the gas plants started out as retort gas plants and those plants that continued into the 1920s or 1930s were either converted to water gas plants or had water gas facilities added to the site. An example of a gas plant (Ottawa Lees Avenue, 1922) with both retort gas and water gas facilities is shown in Figure 3.

GAS PLANT WASTES

Types of Wastes

The major types of wastes and by-products generated in the coal gasification process included:

- tars;
- sludges:

- tar liquors and ammonia liquors;
- spent iron oxide;
- ash, slag, cinders;
- dust, off-grade coal and coke.

From an environmental hazard point of view, the important gas plant wastes are tar residues and sludges and spent oxide wastes.

Tar residues and sludges were produced in the gas clean-up process during the cooling, condensation and scrubbing of the raw gas. On-site tar storage areas, consisting of underground tanks or wells, were usually located adjacent to the condenser or purifying houses. Tar dehydrators and tar separators also contained tar and were either underground or above ground storage tanks. Underground pipelines running from the production areas to the tar storage areas also contained tar. Other locations of residual tar were the base of relief gas holders which would have contained raw gas prior to clean-up and to a lesser extent the base of the main gas holding tanks.

The tar produced at a gas plant was considered a valuable by-product and was often sold to tar distillation plants or domestic consumers. The off-site distillation plants refined the tar to produce such products as naphthalene, creosote, heavy oil, and roofing and road tars. Consequently, little tar was likely to be disposed on-site except when production was greater than demand or where spillage might occur in loading areas. Tar remaining on-site after plant demolition is likely to be found in the original storage areas if the containers are intact. If storage tanks or other tar-containing structures are ruptured during demolition or other on-site excavation or construction, free tar and tar contaminated soil may be widespread across the plant site.

Coal tar and coal tar contaminated material is easily identifiable when encountered because of its distinctive odour which resembles creosote or roofing tar. The tar is typically a brown to

black resinous material with a consistency varying from a light oil to a heavy tar. It is immiscible with, and heavier than, water and therefore exhibits density - dependent flow characteristics. When in contact with surface water, coal tar may release a lighter-than-water phase which causes an oily sheen on the water surface.

Immiscible coal tar in surface water will sink to the bottom of the water body and will collect in depressions.

Spent oxide is a waste product that resulted from the removal of sulphur and nitrogen-containing impurities from the manufactured gas by adsorption onto iron oxide. These wastes contain high concentrations of sulphur, cyanide, and ammonia compounds, most of which are chemically bound with iron. Their characteristic blue-grey colour caused by ferrocyanide complexes make them readily identifiable upon discovery. Such identification is possible in soils with little as 1% spent oxide (ERT, 1984).

Oxide wastes were typically disposed of on-site or adjacent to the site using standard landfilling techniques of the time.

The ash, slag, clinkers, dust and offgrade coal and coke were often disposed on-site or as part of adjacent landfilling operations. These wastes are relatively inert, although they may leach traces of heavy metals.

Chemistry and Environmental Behaviour of Wastes

The major chemicals associated with gas plant waste that may pose an environmental hazard are:

- Polynuclear aromatic hydrocarbons (PAH);
- Light aromatics;
- Phenolics;
- Inorganic sulfur and nitrogen species;
- Trace metals.

PAH, light aromatics and phenolics are derived primarily from the tar sludges and liquors. Table 1 shows physical and chemical properties of typical coal tar constituents and the typical chemical composition of a coal tar. Inorganic species and trace metals are derived primarily from the oxide box wastes and the ammonia liquors. Trace metals may also be generated to a lesser extent from disposal of ashes and cinders.

The tars are mainly composed of polynuclear aromatic hydrocarbons which are compounds consisting of two or more fused benzene rings, light aromatics and phenolics. The physical and chemical properties of PAH are dependent on the structure of individual compounds. The aqueous solubility and volatility of each compound decreases as the molecular weight of the compound increases. Therefore those compounds with a simple structure have higher solubilities and volatilities than those with a complicated structure. PAH are strongly absorbed and immobilized in soils and are also susceptable to biodegradation by microorganisms. Table 1 also lists the logarithm of the octanol-water partitioning coefficient, K_{ow}, which is a measure of the partitioning of coal tar constituents between the water and soil. Larger K_{ow} values indicate a greater affinity for adsorption. As a result of these properties, PAH tend to be relatively immobile in the environment. However, the fact that they occur in tars and that tars can migrate as an immiscible, heavier-than-water phase increases their mobility and potential environmental impact.

Light aromatics, such as benzene, xylene and toluene are moderately soluble, and biodegradeable with high volatility and low sorption. They are expected to be relatively mobile in groundwater systems.

Phenolics (e.g., phenol, cresol and xylenol) are highly soluble with low sorption and high biodegradeability and therefore are expected to be highly mobile in groundwater.

Inorganic sulphur and nitrogen species are usually stable under most normal pH and Eh conditions in groundwater systems. Ammonia and cyanide in spent oxide wastes may be leached under acidic conditions, but these compounds are also known to readily biotransform in aerated soils to simpler nitrite and nitrate compounds.

Most trace metals leached from manufactured gas plant wastes are relatively insoluble and highly sorbed.

HEALTH EFFECTS

The environmental impact and risk associated with manufactured gas plant wastes are derived from exposure and/or contact with hazardous substances. The hazardous substances of primary concern in this respect are associated with coal tar wastes, particularly polynuclear aromatic hydrocarbons and light aromatic hydrocarbons (ERT, 1983; 1984). The environmental impact from these substances results in adverse effects on human health and aquatic and terrestrial ecosystems. The most adverse effect associated with PAH and light aromatic hydrocarbons, is the increased incidence of cancer. Health effects associated with PAH are documented in the literature because of their ubiquitous presence in the environment. PAH are found in polluted air, tobacco smoke, cooking products, soots, tars, and oils. PAH are formed in a variety of hydrocarbon combustion processes routinely exposing most people to very low levels of PAH. In general, PAH are a large group of chemicals of which only a few have been suitably tested with respect to human health effects. The major routes of PAH adsorption are through inhalation and cutaneous exposure.

A recent Ontario Ministry of Labour sponsored study, (Occupational Health Program, McMaster University, 1986) provides a comprehensive review of the available scientific evidence relating to health effects of coal tar and other substances which contain polynuclear aromatic hydrocarbons and light aromatic hydrocarbons. This study concludes that there is sufficient evidence concerning human carcinogenic potential of coal tar products in the literature to

warrant stringent control of workplace exposures. This study recommends an interim standard for occupational exposure to volatiles of coal tar products at 0.05 mg/m^3 (cyclohexane soluable extract) time weighted over an 8 hour working day and zero dermal exposure.

STUDY METHODOLOGY

PHASE 1 HISTORICAL RECORD SEARCH

The search of historical records was undertaken to provide a list of manufactured gas plant waste sites. This involved the identification of manufactured gas plant sites as well as any historical information describing possible off-site disposal of gas plant wastes. Only limited data describing the off-site disposition of gas plant waste was available from historical records. Therefore, the review of historical records focussed on identification and characterization of manufactured gas plant sites.

The method used in this phase relied upon review of a limited number of well selected historical sources to both identify the existence and exact location of sites, and to obtain a comparitive, shallow level of information for each site. The key to this method was the selection of appropriate historical source materials. The historical source materials used in this study can be grouped by use according to site location and site characterization tasks.

Site Location Sources

Sources used for the identification of manufactured gas plant locations varied from period to period. In each case, they were selected by the following criteria: comprehensiveness of coverage, degree of reliability of information contained, degree of site specificity of information contained, potential for including other information (i.e., on relative size, equipment or processes) of relevance to the general purposes of the study. Table 2 summarizes the site location sources by historical period.

Site Characterization Sources

Every attempt was made to obtain a description of the evolution of various manufactured gas plant sites over time to ensure changes in their disposition over time (and therefore a record of landfill, buried tanks, and changed location of gas holding tanks) was recorded.

Historical sources used for the early period included Bird's Eye views, county maps, and county atlas material, selected in each case for the specific details included on site disposition. Figure 4 is an example of a Bird's Eye view of the St. Catharines and Welland Canal gas works in 1875.

Once fire insurance plans appeared in any community, they became the major source used. Such plans were reviewed whenever they existed, although only those showing site changes, or a range of time (i.e., earliest and latest) were purchased. Review of these sources was restricted to the three major collections of fire insurance plans in the province, those at the Public Archives of Canada, Ottawa, the Ontario Archives, Toronto, and the Regional Collection at the University of Western Ontario, London. Enquiries were made to local archives when plans for specific communities were not available in the major collections, and some additional materials have been obtained in this way. Corporate archives such as those of Ontario Hydro and Consumers Gas were also contacted and additional site specific information was obtained from these sources. The preparation of fire insurance plans stopped in the late 1950s, and such plans are not available for many communities after the 1930s or 1940s. Figures 5 and 6 are examples of early (1919) and later (1956) fire insurance plans for gas works located in Windsor and Ottawa, respectively.

Some additional maps of gas plant operations were obtained from current Public Utilities Commissions who at one time owned or operated manufactured gas plants in individual towns and cities.

PHASE 2 SITE RECONNAISSANCE VISITS

Reconnaissance visits and on-site inspections were undertaken for all plant sites, except the Sault Ste. Marie site, identified from Phase 1 activities. The principal purpose of site reconnaissance and inspection was to identify any evidence of wastes by visual and olfactory inspection and any environmental impacts that may be related to the wastes. The site reconnaissance also served to identify land use on-site and off-site, site conditions and site access for possible future investigations and to obtain photographs of and additional local information on the site. Waste site reconnaissance work undertaken as part of this phase did not involve subsurface investigations, such as drilling and soil sampling.

The approach to site reconnaissance was to utilize a consistent and thorough inspection of the waste site in conjunction with available air photos, gas plant plans, and plans of underground utilities including storm sewers.

Because of the visual character of tarry wastes and spent oxide wastes, these gas plant wastes were in principle relatively easy to identify at surface and in the near surface. These wastes also pose the most significant potential health and environmental impact. Cinders, ash, coal fines and clinkers were also readily identified but these materials pose little health or environmental hazard and were only used to confirm the location of the gasification plant.

PHASE 3 ASSESSMENT OF POTENTIAL ENVIRONMENTAL IMPACT

An assessment of the potential environment impact posed by each manufactured gas plant site was performed using qualitative assessment criteria and information on site conditions obtained from local authorities and the site reconnaissance visits.

The criteria for assessment of potential environmental impact of manufactured gas plant sites are listed in Table 3 and are grouped into three important categories: site charactistics, evidence of buried wastes and resource characteristic as suggested by ERT (1984). The three categories are further divided into a number of factors which are used to assess the potential environmental impact of each site. The approach to assessment of potential environmental impact of unexplored gas plant sites is qualitative in nature reflecting the variable, uncertain and conjectural nature of much of the data. Therefore, qualitative scores of high, medium, and low are assigned for each of the factors. For some sites, data is of greater reliability as a result of recent subsurface investigations, but for many of the sites reliable information on subsurface conditions is not available, or at best is poorly reported. Given these considerations, quantitative assessment or ranking of sites with respect to potential environmental impact is not warranted. Also not all factors are expected to have equal weighting at all sites.

PHASE 4 DEVELOPMENT OF OPTIONS FOR FURTHER ACTION

For each site identified from Phase 1 activities, options for further action were developed. These options were developed based on site access, site conditions, the nature and disposition of wastes, the potential environmental impact associated with the wastes and perceived needs for additional information. The options for further action range from notifying and cautioning municipalities and land owners of the likely existence of buried wastes at each site to implementation of site investigations with the intent of developing specific site remediation plans.

RESULTS

List of Manufactured Gas Plant Sites

The historical record search identified 41 manufactured gas plant sites in 36 different communities in Ontario. Table 4 lists these sites with their location and approximate years of operation. These "town gas" plants were located throughout the Province, with the majority of plants located in southern Ontario, close to Lake Ontario and the larger communities of southwestern Ontario. The identified plants operated for periods of 10 to more than 100 years from 1841 to 1963. More than one gas plant site was identified in the communities of Hamilton, Oshawa, Ottawa and Toronto.

Preliminary Assessment of Potential Environmental Impacts of Manufactured Gas Plants

An assessment of the potential environmental impacts of each site listed in Table 4 was completed using the assessment criteria listed in Table 3. The results of the preliminary assessment are given in Table 5 using high (H), medium (M) and low (L) rankings under each factor. The information necessary to complete the assessment of each site is found on the fact sheets for each site (INTERA, 1987). The preliminary assessment is qualitative and reflects the variable, uncertain and conjectural nature of some of the site specific information. The exercise is most useful in identifying categories (site characteristics, evidence of buried wates and resource characteristics) or factors for each site that may indicate a potential environmental impact and to provide a broad overview of each site.

In completing the assessment, the factors concerning visible wastes, odours or water pollution required clarification as to whether the problems were existing or historical occurrences. The distinction is important in terms of the environmental impact because it indicates

a present problem or a problem that may have been more significant in the past. Historical occurrences, however, are just as important as present occurrences in terms of potential environmental impacts in that they may indicate the presence of on-site or off-site wastes, past or future impacted areas or migration pathways. Also for some of the sites where evidence of buried wastes exists, it is not possible to associate the evidence solely with a former gas plant as a result of other industrial waste-producing activities within the area.

SUMMARY

Based on the data collected in this study and the potential environmental impacts identified in Table 5, several former manufactured plant sites have potential for environmental impact as a result of confirmed existence of tars and sludges on-site that are currently or may in the future impact off-site properties and water resources. These high-priority sites include in alphabetical order, Belleville, Guelph, Kitchener, London, Ottawa (King Edward Avenue), Ottawa (Lees Avenue), Peterborough, Port Stanley, St. Thomas, Toronto Station "A" and Waterloo. Remedial actions or studies are currently underway at the sites located in Kitchener, Ottawa (both sites), Port Stanley, Toronto Station "A", Waterloo and Guelph.

Medium-priority sites, where potential environmental impact is less, but where evidence of buried wastes has been reported include in alphabetical order, Barrie, Chatham, Deseronto, Toronto Station "B", Windsor and Woodstock. Work is underway at the Barrie and Woodstock sites.

Low-priority sites are sites where potential environmental impacts are perceived, based on available information, to be minimal. These sites include in alphabetical order, Brampton, Brantford, Brockville, Cambridge, Cobourg, Cornwall, Dundas, Hamilton (two sites), Ingersoll, Kingston, Lindsay, Listowel, Napannee, Oshawa (two sites),

Owen Sound, Port Hope, St. Catharines, Sarnia, Sault Ste. Marie, Simcoe, Stratford and Toronto Station "C". Although these sites are thought to pose minimal environmental impact, the classification of these sites is based only on available information with little data on subsurface conditions. Because of this lack of information on subsurface conditions, any of the sites identified in this study as low or medium priority may be elevated to a higher priority status pending the results of individual site investigations.

Since identification of these former manufactured gas plant sites, the Ontario Ministry of the Environment has allocated $1.7 million to be spent over the next three years to conduct investigative work at certain sites. Recently, the Ontario Ministry of the Environment also performed water quality analyses on municipal water supply wells proximate to the former gas plants at Ingersoll, Listowel, Stratford and Waterloo. This sampling showed no PAH contamination of these drinking water supplies.

This inventory study identified and assessed former gas plants which produced gas for municipal lighting and heating and likely the most significant volumes of coal tars. Other sites including industrial coal gasification plants and secondary tar refineries are also known to have handled hazardous coal tars and the Ontario Ministry of the Environment will also study these sites.

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Table 1 Physical and Chemical Properties of Typical Coal Tar Constituents

Constituent	Formula	Molecular Weight	Aqueous Solubility (mg/L)	Log K_{ow}[6]
PAH				
Naphthalene	$C_{10}H_8$	128.16	31.7[1]	3.37
Acenaphthylene	$C_{12}H_8$	152.21	3.9[5]	-
Acenaphthene	$C_{12}H_{10}$	154.21	3.93[1]	4.33[8]
Fluorene	$C_{13}H_{10}$	166.21	1.98[1]	4.12[5]
Anthracene	$C_{14}H_{10}$	178.22	0.073[1]	4.45
Phenanthrene	$C_{14}H_{10}$	178.22	1.29[1]	4.46
Fluoranthene	$C_{16}H_{10}$	202.26	0.26[1]	-
Pyrene	$C_{16}H_{10}$	202.24	0.135[1]	4.88[5]
1,2-Benzoanthracene	$C_{18}H_{12}$	228.28	0.014[1]	5.61[7]
Chrysene	$C_{18}H_{12}$	228.28	0.002[1]	5.61[7]
Benzo(a)pyrene	$C_{20}H_{12}$	252.30	0.0038[1]	6.04[7]
3,4-Benzofluoranthene	$C_{20}H_{10}$	252.32	0.0015[2]	6.7[8]
Benzo(ghi)perylene	$C_{22}H_{12}$	276.34	0.00026[1]	7.23
Indeno(1,2,3-cd)pyrene	$C_{22}H_{12}$	276.34	0.0002[2]	-
Dibenz(a,h)anthracene	$C_{22}H_{14}$	278.00	0.0005[4]	5.97[8]
Light Aromatics				
Benzene	C_6H_6	78.11	1780.[3]	2.13
Toluene	C_7H_8	92.13	538.[3]	2.69
Ethylbenzene	C_8H_{10}	106.16	159.[3]	3.15
Phenolics				
Phenol	C_6H_5OH	94.	82000.[6]	1.46
Meta-Cresol	$CH_3C_6H_5OH$	109.	23500.[6]	1.98

Notes:
1 Data from Mackay and Shiu (1977)
2 Data from NBS (1981)
3 Data from McAuliffe (1963)
4 Data from Pearlman et al. (1983)
5 Data from Lyman et al. (1982)
6 Data from Verschueren (1983)
7 Data from USEPA (1980)
8 Data from Versar (1979)

Table 2 Historical Sources Used to Identify Manufactured Gas Plant Sites

Period	Historical Source
1850 - 1870	• Lists in the American Gas - Light Journal • Ontario Directories
1870 - 1905	• Canadian Census Material • Baudouin Index to Incorporated Bodies (Baudouin, 1897) • Ontario and Local Municipal Directories • Historical Societies • Corporate and Local Archives
1905 - 1920	• Intercolonial Gas Journal • Ontario Government Records on Company Incorporations • Ontario Energy Board Franchise Agreements • Ontario Select Committee on Municipal Trading and Municipal Ownership of Public Utilities Report
1919 - 1959	• Dominion Bureau of Statistics Listings for Plants for: - Gas for Illumination and Fuel Purposes - Coke and Coke By-Products Industries • Ontario Energy Board Records • Correspondence of the Special Fuel Controller, Province of Ontario (1922-28) • Canadian Gas Association Records

Table 3 Assessment Criteria for Potential Environmental Impacts of Manufactured Gas Plant Sites in Ontario

Factors	Criteria for Assessment		
Level	Low	Medium	High
Site Characteristics			
Size (when operated)	<0.5 hectares	0.5-1.0 hectares	>1.0 hectares
Location	rural or sparsely populated	industrial or commerical area	residential or public use area
Current Use/Ownership	controlled access, industrial or commercial use	owned and used industrially or commercially with uncontrolled access	used residentially or publicly
Planned Use/Ownership	continued ownership and industrial or commerical use	sale for industrial or commerical use	sale or conversion to residental or public use
Potential for Excavation	no plans for redevelopment	possible redevelopment	redevelopment planned
Evidence of Buried Wastes			
Operating Period	<30 years	30-60 years	>60 years
Excavation History	excavation, no wastes reported	no excavation	excavation, waste encountered
Visible Wastes (Tars and Spent Oxide)	none or very minor	minor pockets	extensive
Odour	none on-site	minor on-site	distinct on-site
Water Pollution	no visible presence	oily or discoloured water on-site	oily or discoloured drainage off-site
Resource Characteristics			
Surface Water Proximity	>1 km	<1 km but not adjacent	adjacent
Surface Water Use	industrial	recreational	drinking water
Groundwater Proximity	site directly on low permeability soils or bedrock	site on permeable soils with confining layer above aquifer	direct groundwater connection to major aquifer
Groundwater Use	no wells in possible impacted areas	industrial or a few private wells	public water supply wells

Table 4 List of Manufactured Gas Plant Sites in Ontario
1841-1963

Community	Address	Approximate Years of Operation
Barrie	17-31 Kempenfelt Dr. between Sampson and Duckworth Sts.	1878-1939
Belleville	110-118 Church St. between St. Paul and Dundas St. E.	1854-1947
Brampton	Northeast corner of Nelson and George Sts.	1888-1917
Brantford	East Ave. bounded by Alfred, Newport, East and Colborne Sts.	1860-1911
Brockville	40 St. Paul St. bounded by St. Paul and King Sts. and Butlers Creek	1853-1957
Cambridge (Galt)	140 North Water St. bounded by Grand River and opposite Simcoe St.	1887-1911
Chatham	307 King St. W. bounded by Second Sts., King St. W., Third St. and Thames River	1873-1929
Cobourg	Between Queen and Charles Sts. west of McGill St. and east of Division St.	1857-1937
Cornwall	S.W. corner Water St. E and Amelia St.	1882-1929
Deseronto	South side of Main St. between First - Second St.	1886-1920
Dundas	43 Cootes Dr. on E. side of Thorpe and King St. E.	1863-1909
Guelph	118-124 Fountain St., N.W. corner of Fountain & Wyndham Sts.	1871-1957
Hamilton	1. N. and S. of Mulberry St. between Bay North & Park North St.	1850-1925
	2. Hamilton By-Product Coke Ovens, Burlington-Industrial Depew St. area	1924-1958
Ingersoll	83 Avonlea St, N. end of Avonlea St. at railway tracks	1876-1915
Kingston	Bounding blocks, Place D'Armes, Ontario, Queen and Barrack Sts.	1848-1957
Kitchener	Gaukel St. bounded by Joseph and Charles Sts.	1882-1958
Lindsay	66 William St., S.E. corner of William and Wellington Sts.	1881-1890
Listowel	46 Elma St. between Livingstone Ave. E. and Maitland River	1891-1915
London	Area bounded by Thames, Horton, Simcoe, Bathurst and Ridout Sts.	1853-1939
Napanee	96 Water St., S.W. corner of Water and West Sts.	1880-1921
Oshawa	1. West corner of Centre and Bond Sts.	1903-pre 1928
	2. 80 Emma St. at CN Railway Line (Old Prospect St.)	1901-1954
Ottawa	1. S.W. corner of York and King Edward Sts.	1854-1915
	2. 175 Lees Ave.	1920-1957
Owen Sound	1141-1145 First Ave. E.	1888-1947
Peterborough	N. side of Simcoe St. between Queen St. and Railway Line, adjacent to Otonabee River	1869-1950
Port Hope	70-80 John St., W. side of John St. between Park and Alexander Sts.	1859-1938
Port Stanley	Carlow Road bounded by Marr Rd., Carlow Rd., Lake Rd., and George St.	1945-1958
St. Catharines	S. of Gale Crescent, bottom of Calvin St., beside Old Welland Canal	1853-1928
St. Thomas	Corner of Mondamin and Gas Sts.	1877-1935
Sarnia	Maxwell St. bounded by Maxwell, Water, Front Sts. and Railway tracks	1884-1909
Sault Ste. Marie	Goulais Ave. bounded by Bonney, Baseline, Pittsburgh and Goulais Sts.	1925-1963
Simcoe	S.E. corner of Pond and Water Sts.	1891-1910
Stratford	Wellington St., bounded by St. Patrick, Nelson, St. David and Erie Sts.	1879-1953
Toronto	1. Station A, 271 Front Street area of Princess, Berkeley, Front, Parliament and Trinity Sts.	1841-1954
	2. Station B, 415 Eastern Ave., N.E. corner of Booth St. and Eastern Ave.	1909-1954
	3. Station C, 28 Bathurst St., N.W. corner of Bathurst St. and Front St. W.	1909-1954
Waterloo	E. side of Regina St. and W. side of William St., S. of Laurel Creek	1889-1957
Windsor	S. of McDougall Ave. opposite the S.W. extension of Brant St.	1871-1930
Woodstock	Young St. bounded by Young, Peel, Burtch Sts. and an open area	1876-1919

Table 5 Assessment of Potential Environmental Impacts of Manufactured Gas Plant Sites in Ontario

Site Name & Location	Site Characteristics					Evidence of Buried Wastes					Resource Characteristics			
	Size	Location	Current Use/ Ownership	Planned Use/ Ownership	Potential for Excavation	Operating Period	Excavation History	Visible Waste	Odour	Water Pollution	Surface Water Proximity	Surface Water Use	Ground-water Proximity	Ground-water Use
Barrie	L	H	H	H	H	H	H	L[h]	H[h]	L	H	M	M	M
Belleville	M	H	H	M	M	H	H	H[h]	M[p]	H[h]	M	H	L	L
Brampton	L	M	M	L	L	L	L	L	L	L	M	M	L	L
Brantford	M	H	M	L	L	M	L	L	*[p]	*[p]	H	M	L	L
Brockville	M	H	H	L	L	H	L	L	L	L	H	M	L	L
Cambridge (Galt)	L	M	M	H	H	L	L	L	L	L	H	M	L	L
Chatham	H	H	H	L	L	M	H	M[h]	L	L	H	M	L	L
Cobourg	L	H	M	L	L	H	L	L	L	L	M	M	L	L
Cornwall	L	H	H	L	M	M	L	L	L	L	M	H	L	L
Deseronto	L	H	H	H	H	M	H	M[h]	H[h]	L	H	M	L	L
Dundas	L	M	M	L	M	M	M	L	L	L	M	M	L	L
Guelph	H	H	H	L	M	H	H	M[h]	L	L	M	M	L	L
Hamilton (Depew-Burlington) area)	H	M	L	L	L	M	M	*[p]	*[p]	*[p]	H	L	L	L
Hamilton (Mulberry)	H	H	M	L	M	H	L	L	L	L	M	L	L	L
Ingersoll	L	H	L	L	L	M	M	L	L	L	M	M	M	M
Kingston	H	H	H	L	L	H	H	M[p]	L	L	M	M	L	L
Kitchener	H	H	H	H	H	H	H	H[p]	L	M[h]	M	M	M	L
Lindsay	L	H	H	L	L	L	M	L	L	L	M	M	L	L
Listowel	L	M	M	L	L	L	M	L	L	L	H	M	M	M
London	H	H	H	L	M	H	H	H[p]	L	H[p]	H	M	L	L

* Positive identification, however wastes may not be solely attributable to former gas plant as a result of other industrial activities within the area.

[h] evidence from historical reference

[p] evidence from observation during the course of this study

Table 5 Assessment of Potential Environmental Impacts of Manufactured Gas Plant Sites in Ontario

Site Name & Location	Site Characteristics					Evidence of Buried Wastes					Resource Characteristics			
	Size	Location	Current Use/ Ownership	Planned Use/ Ownership	Potential for Excavation	Operating Period	Excavation History	Visible Waste	Odour	Water Pollution	Surface Water Proximity	Surface Water Use	Ground-water Proximity	Ground-water Use
Napanee	L	H	H	L	H	M	L	L	L	L	H	M	L	L
Oshawa (Bond)	L	M	M	L	L	L	L	L	L	L	M	M	L	L
Oshawa (Emma)	M	H	L	L	L	M	M	M^h	L	L	M	M	L	L
Ottawa (King Ed.)	H	H	H	L	H	H	H	H^p	M^p	M^p	L	M	L	L
Ottawa (Lees)	H	H	H	L	H	M	H	H^p	H^p	H^p	M	M	M	L
Owen Sound	M	H	M	L	L	M	M	M^h	L	L	H	M	L	L
Peterborough	H	H	H	L	M	H	H	H^h	M^p	H^h	H	M	L	L
Port Hope	L	H	H	L	M	H	M	L	M	L	M	H	M	L
Port Stanley	H	M	M	M	M	L	H	$*^p$	$*^p$	$*^p$	H	M	L	L
St. Catherines	H	H	H	H	L	H	M	L	L	L	H	L	L	L
St. Thomas	H	H	H	L	M	M	H	M^h	L	L	M	M	L	L
Sarnia	M	H	L	H	M	M	M	L	L	L	H	H	M	L
Sault Ste. Marie	M	M	L	L	L	M	M	L	L	L	M	M	L	L
Simcoe	L	H	H	L	L	L	M	L	$*^h$	L	H	M	L	L
Stratford	H	H	M	L	L	H	L	L	L	L	M	M	M	H
Toronto "A"	H	H	H	H	H	H	H	H^p	H^p	M^h	M	M	L	L
Toronto "B"	H	H	H	L	L	M	H	H^h	L	L	M	H	L	L
Toronto "C"	H	H	L	L	L	M	M	L	L	L	M	M	L	L
Waterloo	M	H	H	L	H	H	H	H^p	H^p	M^p	H	M	M	H
Windsor	M	H	H	L	M	M	M	M^h	M^p	L	M	M	L	L
Woodstock	L	H	H	H	H	M	H	H^p	M^p	M^p	M	M	L	M

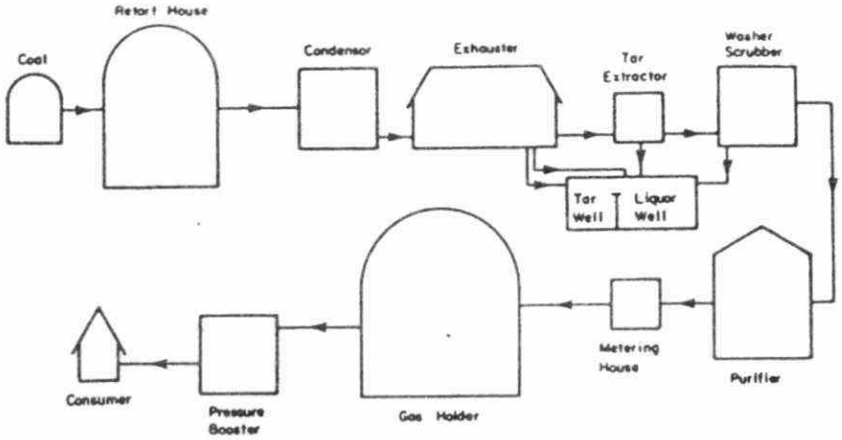

Figure 1 Material Flow Schematic for a Typical Retort Gas Plant

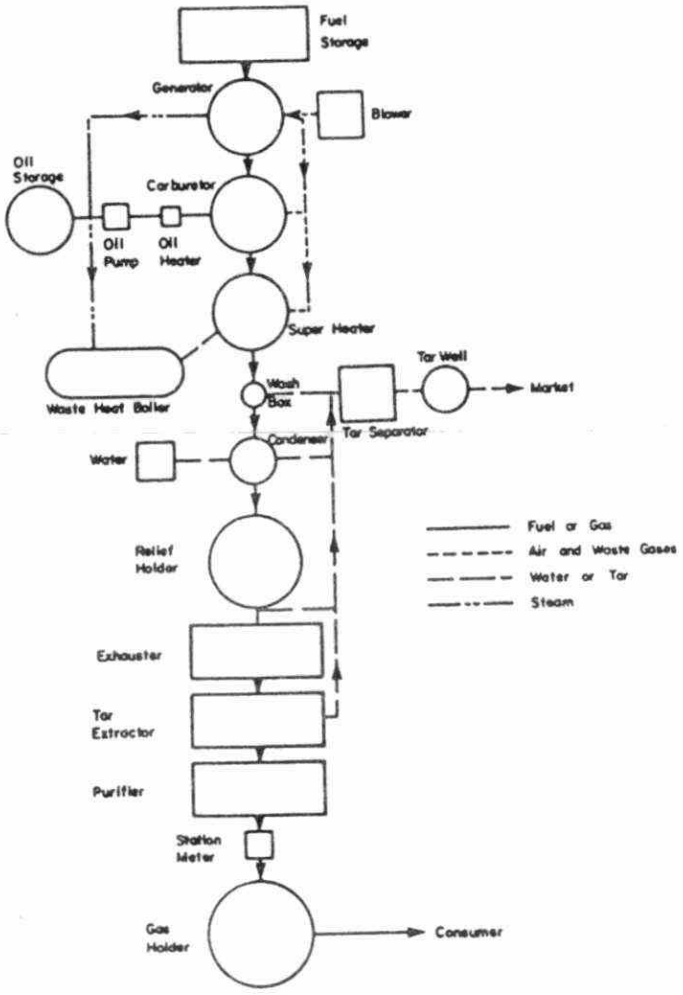

Figure 2 Material Flow Schematic for a Typical Water Gas Plant (after Morgan, 1945, p.1722)

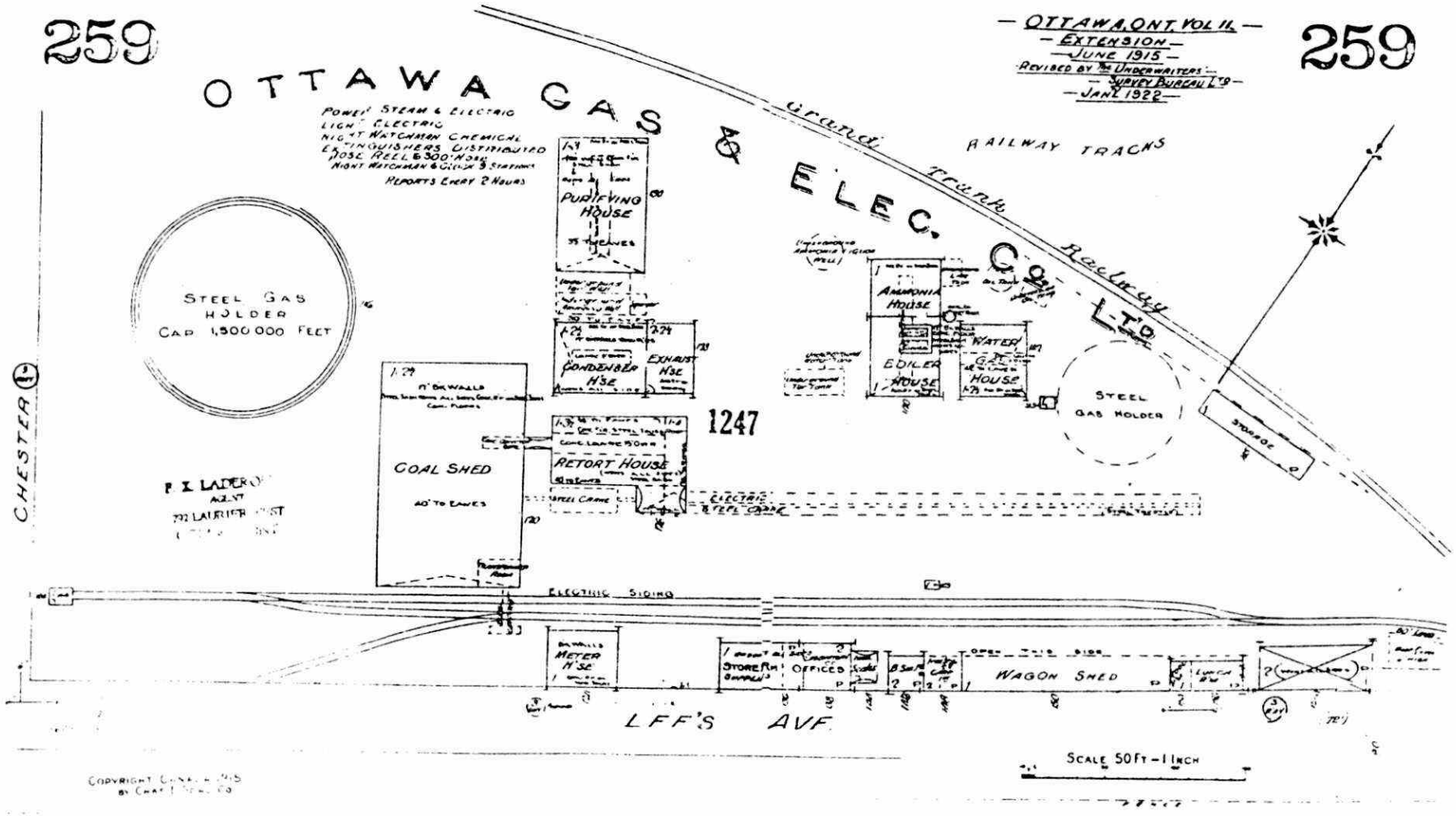

Figure 3 Ottawa Gas Works, 1922, showing Retort and Water Gas Manufacturing Facilities, (Source: Public Archives Canada, NMC10837, Sheet 259)

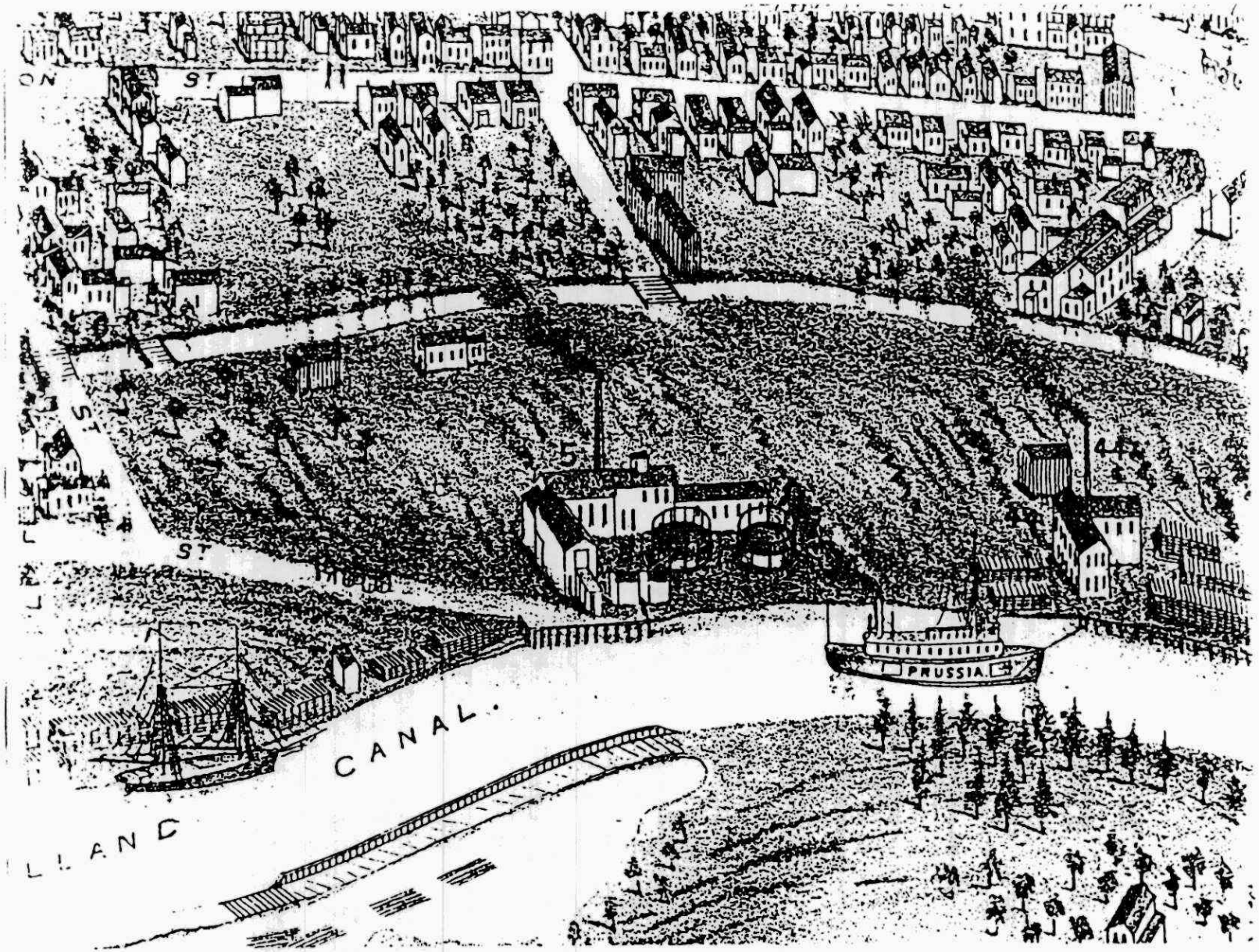

Figure 4 Blow-up of Part of 1875 Bird's Eye View, Showing St. Catharines and Welland Canal Gas Works (Source: Public Archives Canada, NMC22769.)

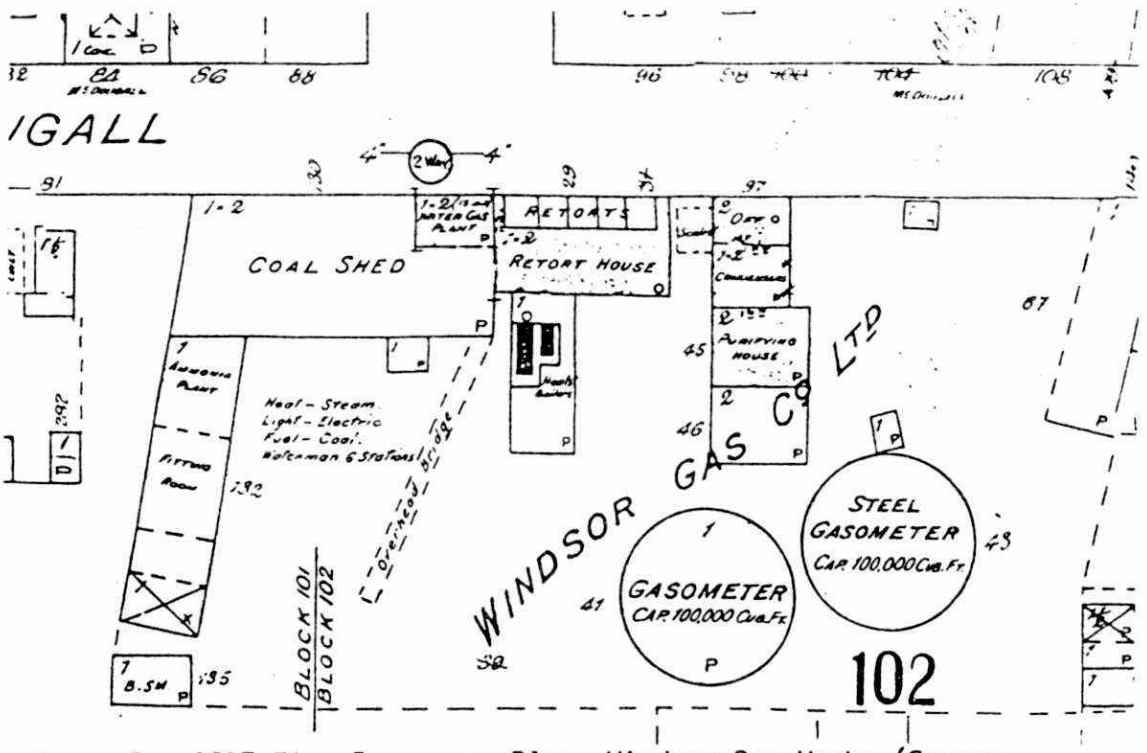

Figure 5 1917 Fire Insurance Plan, Windsor Gas Works (Source: Regional Collection, University of Western Ontario, Sheet 7)

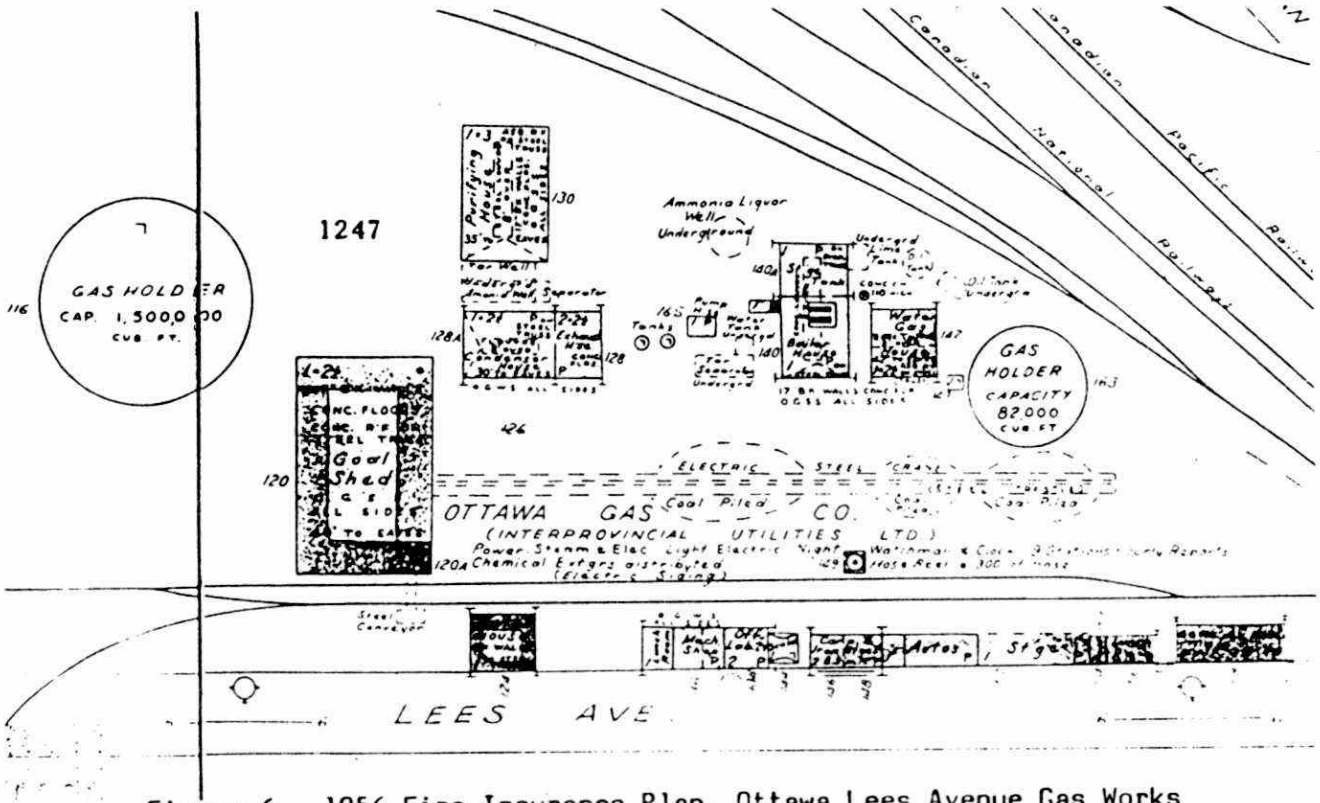

Figure 6 1956 Fire Insurance Plan, Ottawa Lees Avenue Gas Works (Source: Public Archives Canada, NMC, Vol.2, 234-4)

REMEDIATION OF LEES AVENUE TRANSITWAY STATION AND RIDEAU RIVER COAL TAR CONTAMINATION

by

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Conestoga-Rovers and Associates, Waterloo,
Ontario

BACKGROUND

Ottawa's Transitway system consists of a dedicated bus roadway network with widely spaced stations. The busway at the Lees Avenue station would typically carry approximately 140 buses per hour during rush hour (both directions). The Lees Avenue station is situated below ground to allow the Transitway to pass under Highway 417 (the Queensway), which abuts the Transitway site on its north side. Approximately 400 m south of the Queensway underpass, the Transitway goes over the Rideau River (Figure 1).

Because the station is situated close to the Rideau River, and since the roadway is at a lower elevation than the river surface, groundwater flow into the area is substantial. Also, the station is the low point for stormwater for a considerable segment of Transitway. As a result, a system for collecting and pumping groundwater and stormwater was required. The groundwater was collected with collector tiles, and through leakage points in the storm sewer. This water drained to a stormwater lift station, which pumped stormwater and groundwater to a discharge sewer draining into the Rideau River.

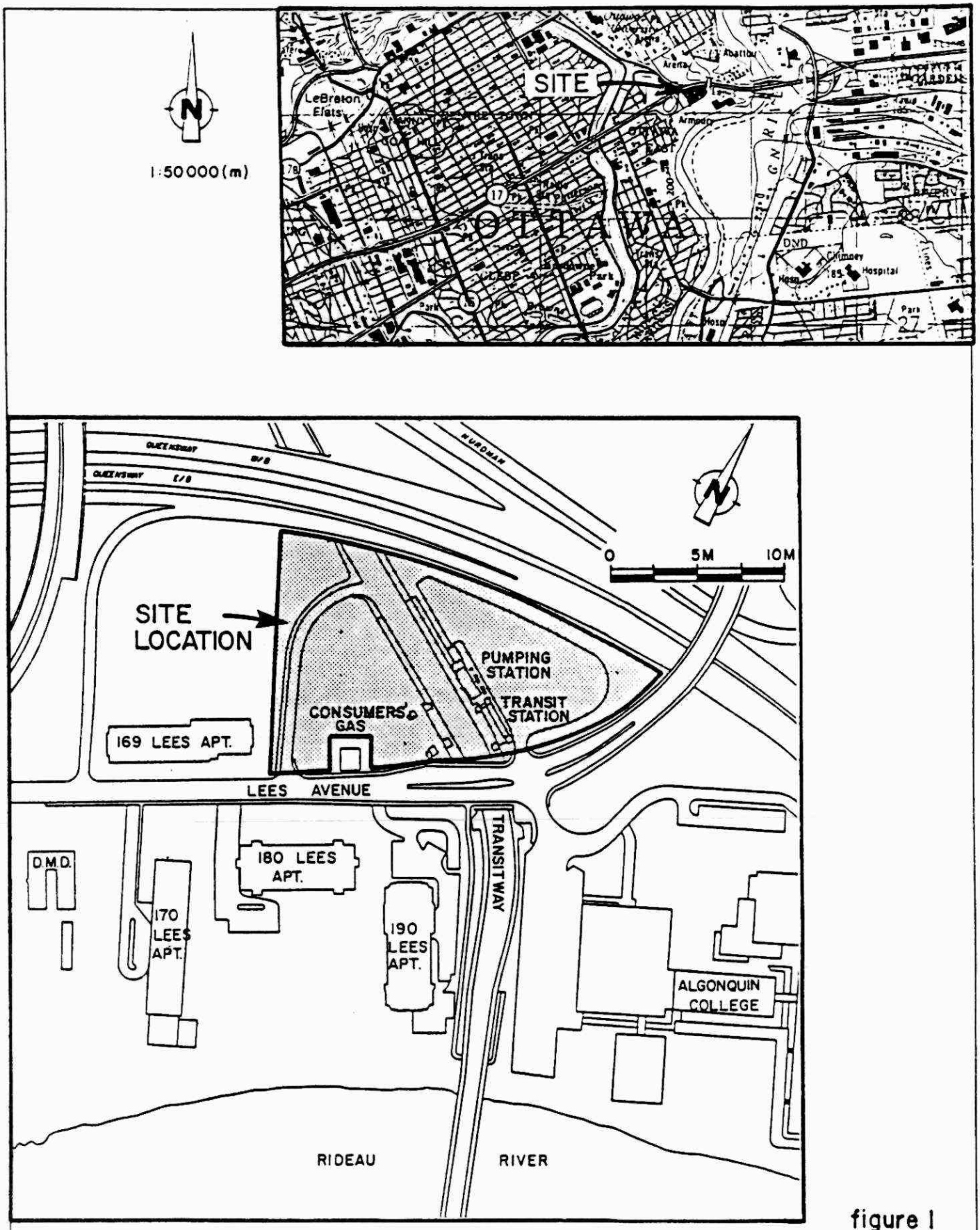


figure 1

SITE LOCATION
LEES AVENUE TRANSITWAY STATION
Regional Municipality of Ottawa-Carleton

CRA

1801-16/06/87-D-0

In April 1986, oily slicks on the surface of the Rideau River were traced to the storm sewer which received water from the pumping station at the Lees Avenue Station. A black tarry substance was found in the storm sewer, in the pumping station well and in the sewers in the Transitway.

Subsequently, the tarry substance was identified as coal/oil tar, and the site of the Lees Avenue station was identified as the former site of a manufactured gas plant.

The tar found at the Lees Avenue site is a residual by-product of coal/oil gasification conducted at the former manufactured gas plant. These tars typically contain a number of hazardous and potentially hazardous compounds, including the polynuclear aromatic hydrocarbons (PAHs), light aromatics and phenolics.

Gas manufacture began at the Lees Avenue site in the 1920's and ceased in 1957 as a result of the advent of natural gas from the West. Although the plant was demolished in 1966, most of the in-ground structures were apparently left in place. One or more of the vessels left in place contained tar.

In 1981, when construction of the Lees Avenue section of the Transitway began, in-ground structures and tar were encountered. At that time, no particular significance was attached to the tar. Some "contaminated liquids" and concrete structures were removed to allow construction to proceed, and in 1983, the Transitway station and the related stormwater pumping station were completed.

In April 1986, tar was found to be leaking into the storm sewer in the below ground Transitway.

Inspection by the City of Ottawa, the owner (the Regional Municipality of Ottawa-Carleton (RMOC)), and the Ministry of the Environment (MOE) suggested that tar was entering the storm sewer through the open bottom of one particular manhole in the Transitway.

The consulting firm which had designed and supervised the construction of the Transitway (M.M. Dillon Limited), were retained by the RMOC to investigate. In order to prevent the further migration of tar, the pumping station was shut down, tar and water were hauled off site for disposal (at a cost of $1.00 per gallon), and a program to divert water before it entered the contaminated area was implemented by the RMOC Works Department. While some measures to protect personnel were taken, a health and safety plant was not developed for this work.

From the period of late April to May 21, 1986 a total of approximately $2.1 million was spent on control coal tar emmissions and investigations. The bulk of this cost was due to the high cost of disposal of the contaminated water.

In late May, Conestoga-Rovers & Associates (CRA) was retained to take over the investigation and manage the emergency response because of their expertise in environmental remediation. Through previous experience in dealing with coal tars and recognizing the potential health effects of coal/oil tars, CRA began the phase-in of a health and safety plan under the direction of CRA's toxicologist and industrial hygienist. At the same time, CRA restructured the emergency measures in order to reduce the cost of handling/treating/disposing of contaminated water.

Prior to commencing remediation of the Lees Avenue Transitway Station in September 1986 an additional

$2.4 million was spent on treatment, various investigations and design of a remediation plan. The total cost to September 1986 had now risen to $4.1 million.

The MOE had retained two consultants for the project, one to investigate "off-site" hydrogeology (Intera Technologies Limited, of Ottawa), the other to evaluate any impact on the Rideau (The Proctor and Redfern Group Limited, of Toronto (R&R)). Both commenced work in mid-July.

LAND INVESTIGATION

CRA took measures to more effectively isolate unimpacted water in the sewers from contamination. A temporary treatment system to separate tar and treat contaminated water was designed and constructed. This system included an API-type (API-American Petroleum Institute) separator. Tarry materials were separated and sent for incineration contaminated water was filtered for particulates, treated by granular activated carbon (GAC), and discharged to the sanitary sewer (Figure 2).

In order to determine the source(s) and extent of contamination, a hydrogeologic investigation was conducted by CRA, beginning in early July 1986. Drilling locations were selected based on process drawings of the plant and aerial photographs. The sites of former structures which potentially contained tar were drilled. In some boreholes, observation wells to monitor contamination and hydrogeologic information were installed. The drilling program was substantially finished by late July. Some off-site drilling was conducted by CRA to provide additional data required to prepare a remedial design for the site.

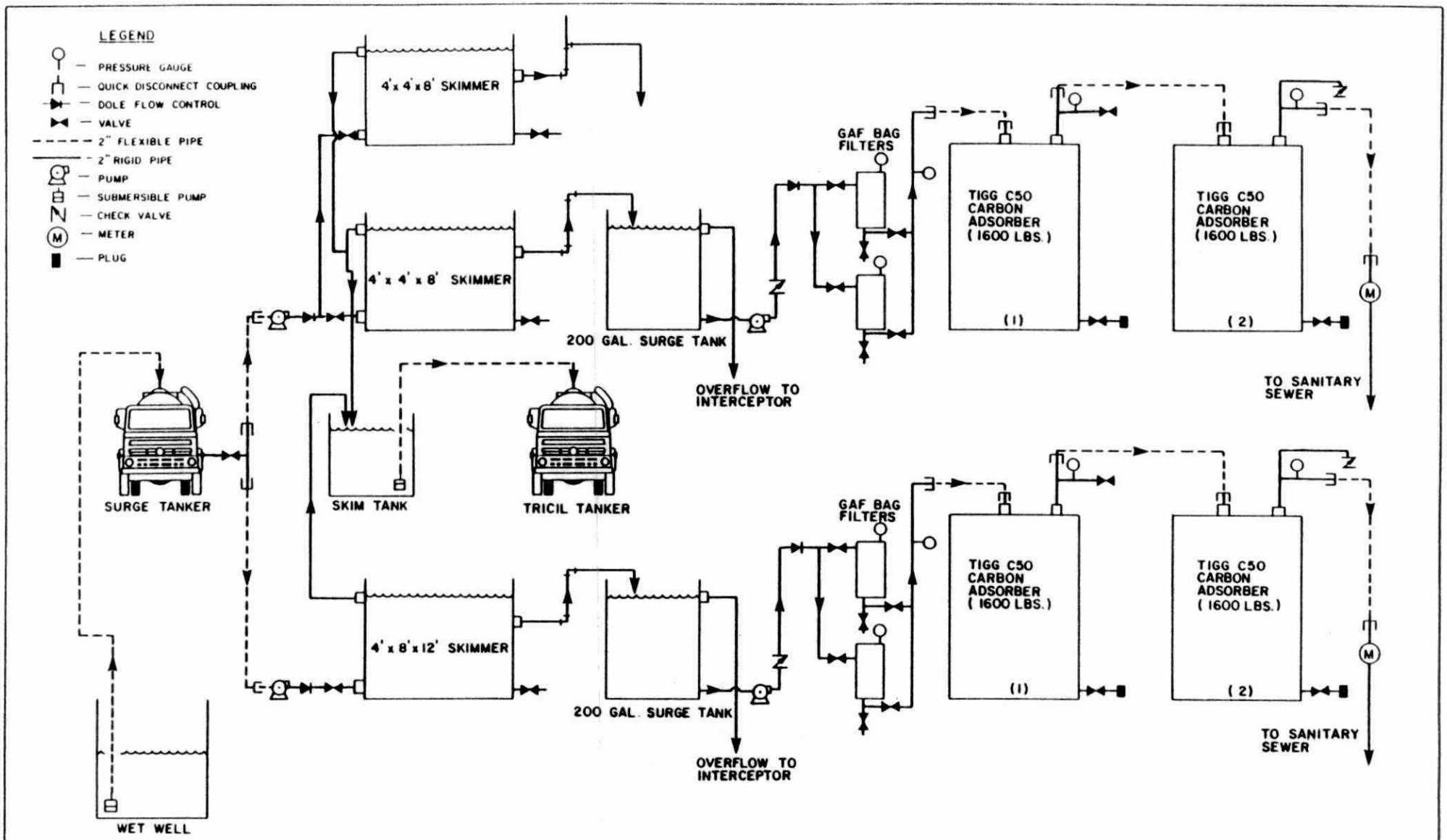


figure 2

TREATMENT PLANT SCHEMATIC
LEES AVE TRANSIT STATION
Regional Municipality of Ottawa / Carleton

CRA

1801-16/06/87-D-0

Observation wells were sampled and samples were analyzed for indicator parameters selected on the basis of the gas manufacture process. The information obtained from the borehole/well drilling and monitoring program was then compiled, and measures to remediate the tar were evaluated.

The MOE's hydrogeologic consultant investigated a number of possible off-site sources of contamination and contaminant migration by a drilling/sampling program, and determined that tar was presently associated with some structures from the gas plant not on RMOC property, as well as some tars likely associated with a creosote plant located nearby. Discontinuous areas of tar and contaminated groundwater were found in a number of locations in the area, consistent with the history of the area. Their report, not yet released, is to detail the extent of contamination and recommend remedial alternatives.

In early September 1986, after CRA had completed remedial evaluation and design, a contract was awarded to Sevenson Construction Limited (St. Catharines) to construct the proposed remedial measures in the Transitway. The program included several components:

1) Cleaning and lining of sewers of all potentially affected sewers in the Transitway using the In Situ Form process, and sealing of the bottom of open bottomed manholes.

2) Cleaning and purging of the wet well in the pumping station, as well as all catchbasins and manholes.

3) Cleaning of the pumps, discharge chamber and discharge sewer by hot water high pressure wash.

4) Installation of a leachate collection tile to collect groundwater and tar from the fill below the Transitway road surface (Figure 3).

5) Installation of a permanent leachate pumping and treatment system.

Perforated clay tile pipe was installed in clear stone. The clay pipe drains to two double-walled pump tanks inside the pump station which then pump to the treatment system which was placed adjacent to the pumping station in the parking area east of the Transitway.

These measures were designed to address the problem defined by CRA's hydrogeologic program. During excavation of the trench in the transitway for the collection tile, tar was found to be present in the fill/overburden material for slightly less than 30 m. Total length of tile in the Transitway is just over 100 m. The collection system has a cone of influence which includes the contaminant plume(s) which had originated from the RMOC property, and thus the system should prevent any further off-site migration.

The now coal tar free stormwater runs in the epoxy-lined sewer, is pumped to the river as previously. Groundwater is collected and pumped to a treatment facility on the Lees Avenue site. The treatment system is similar in concept to the temporary facility, with API separator, particulate filtration and GAC treatment. Organics removed by the system are collected and periodically sent for incineration. Cleaned water is discharged to the sanitary sewer. The system is under automatic control, but requires approximately weekly visits to change filter media in the particulate filters, and backwash the GAC units.

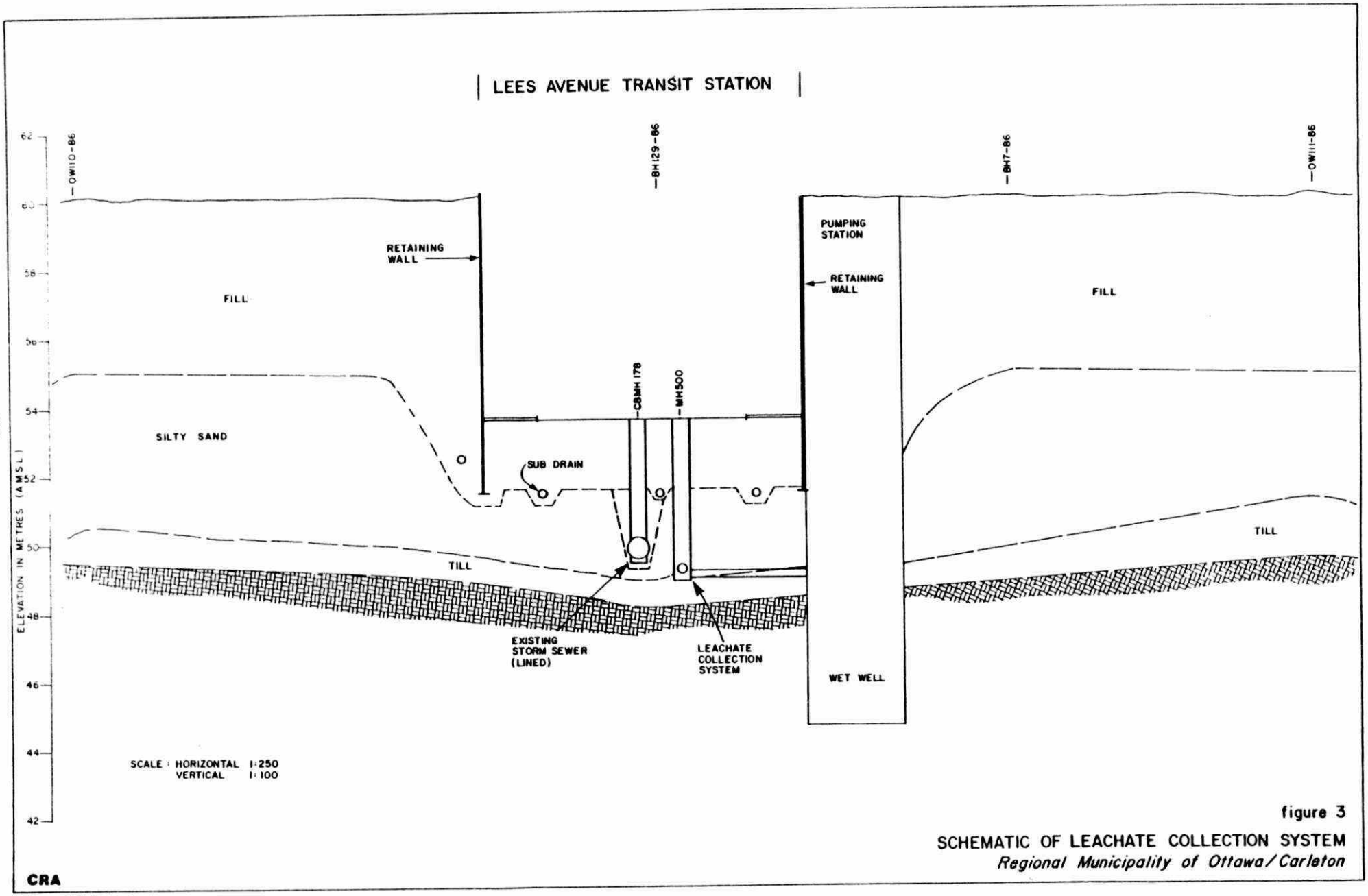


figure 3

SCHEMATIC OF LEACHATE COLLECTION SYSTEM

Regional Municipality of Ottawa/Carleton

The construction of the system was completed in late November 1986, although minor operating modifications continued until April 1987.

The total cost for remedial land work during 1986 including emergency response, site characterization, water treatment, monitoring, design, construction and removal of hazardous material was $3.0 million. It is estimated that an additional cost of $0.9 million will be incurred for continuation of remedial work in 1987 for site restoration and waste removal.

At the Lees Avenue site, plans are being developed to restore the areas adjacent to the station disturbed during the excavations, as well as the facilities used during the remedial investigation and construction. Some contaminated soils remain to be removed from the site, and contract specifications are being prepared at this time. This work is to commence in July 1987.

RIVER INVESTIGATION

Tar slicks on the river originally identified that a discharge of tar was going on. The MOE selected a consultant (P&R) to investigate the river and to report on any contamination. In early July, just prior to the mobilization of the MOE consultant to the river, tar, which had not been observed in the river since pumping from Lees Avenue had ceased in early June, was observed surfacing downstream of the Transitway bridge over the Rideau.

Tar globules were found to be scattered over the bottom of the river in an area approximately 40 m by 160 m, downstream of the storm sewer outlet (Figure 4).

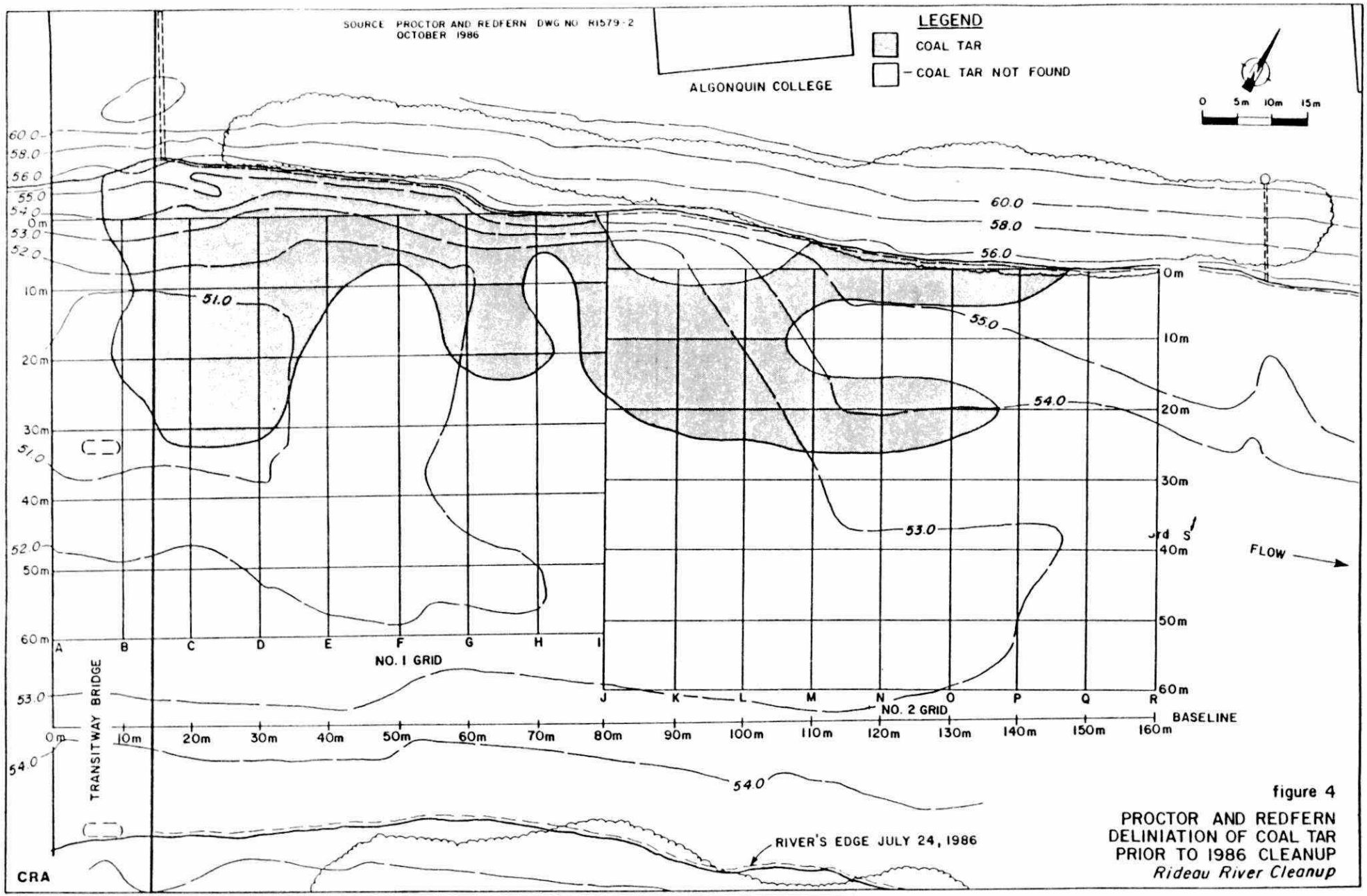


figure 4

PROCTOR AND REDFERN
DELINIATION OF COAL TAR
PRIOR TO 1986 CLEANUP
Rideau River Cleanup

1801-16/06/87-D-0

Visual inspections of the river bottom indicated that tar was present as organic phase globules, generally on top of, perhaps thinly covered by, the sediment. The globules ranged in size from slightly smaller than a grain of rice to 50 cm across. Some small pools of tar, up to several square meters in area and several centimeters deep, were found in depressions in the bottom. The amount of tar on the river bottom before the first phase of cleanup began was estimated to range form 1000 litres to 10,000 litres of liquid tar.

The consultant report, prepared in early September 1986, recommend that remedial measures be undertaken in fall 1986 because of the risk of downstream transport of the tar.

After negotiation with the MOE, the RMOC agreed to undertake the river cleanup. RMOC retained the P&R to supervise the 1986 river remedial activities, and the cleanup commenced in early November 1986.

The cleanup was conducted by OH Materials of Canada and Ottawa Diving Services using a vacuum dredging system (diver-monitored, semi-continuous flow, surface controlled 7.5 cm vacuum hose). Loose sediment and tar were vacuumed off the surface of the underlying riverbed materials. The resulting mixture was pumped to shore, where it was cycloned to remove the solids. Liquid passing the cyclone was treated (using a number of filtration steps with GAC as a final polishing step) and discharged to the sanitary sewer. In early December, the cleanup was forced to shut down before it was completed, by inclement weather.

During the 1986 phase of the cleanup, approximately 30 percent of the area proposed for cleanup was

cleaned of approximately 80 percent of the tar in that area. This included most of the depression immediately downstream of the sewer, and generally included the most heavily contaminated areas. About 260 cubic meters (wet volume, about 60 cubic meters dry volume) of sediments were removed. The heaviest areas of contamination were dredged once. Subsequent re-inspections showed re-deposition of tar in some areas, most likely from tar missed/disturbed on the first cleaning pass. Costs for the 1986 River remediation totalled $2.2 million for installation of the silt curtain, dredging, water treatment and sampling.

In order to consolidate consulting efforts, the RMOC retained CRA to complete the river cleanup in 1987. A contract was prepared for tender the Sevenson Construction was selected to complete the cleanup. Work is expected to commence in early July 1987. In 1987, "spot" removal (diver-controlled vacuum using a 2.5-4 cm hose, non-continuous flow) will be used in areas where only scattered globules are evidenced, and areas with denser concentrations of globules will be vacuumed using a system similar to that used in 1986. Careful inspection of the river bottom by divers has closely defined the areas to be cleaned (Figure 5).

A streamlined treatment process will be used this year, consisting of coagulant addition, sedimentation, sand filtration and discharge. The work is expected to require approximately eight weeks to complete.

It is estimated that the remedial work required to complete the river clean-up during 1987 will cost $0.5 million including costs for continued dredging, water treatment and sampling and the removal of rip-rap.

The total cost of all activities associated with the river and land remediation is expected to be approximately $12 million.

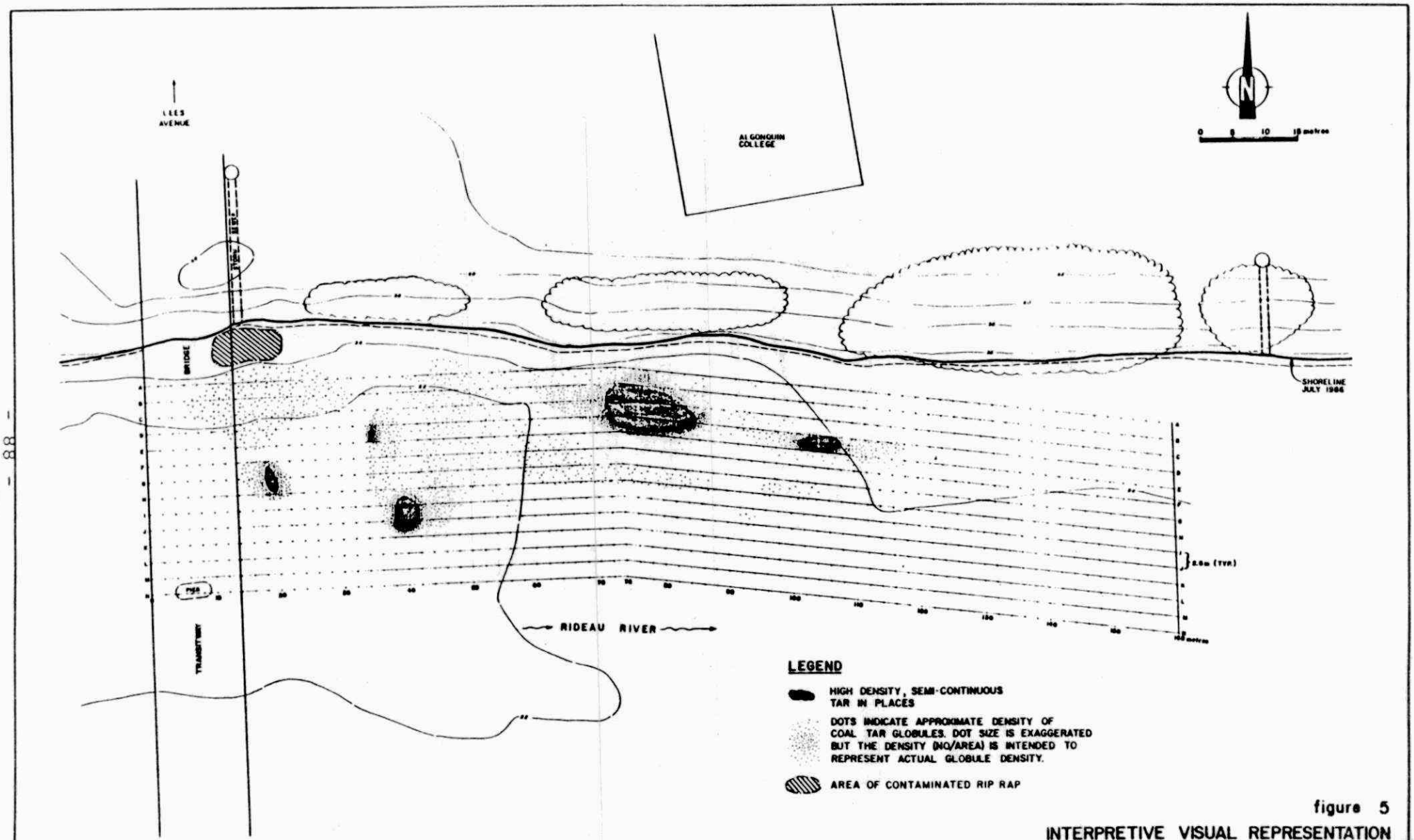

LEES AVENUE
ALGONQUIN COLLEGE
N
0 5 10 15 metres
BRIDGE
SHORELINE JULY 1984
RIDEAU RIVER
TRANSITWAY
LEGEND
HIGH DENSITY, SEMI-CONTINUOUS TAR IN PLACES
DOTS INDICATE APPROXIMATE DENSITY OF COAL TAR GLOBULES. DOT SIZE IS EXAGGERATED BUT THE DENSITY (NO/AREA) IS INTENDED TO REPRESENT ACTUAL GLOBULE DENSITY.
AREA OF CONTAMINATED RIP RAP

figure 5

INTERPRETIVE VISUAL REPRESENTATION
OF COAL TAR CONTAMINATION
Regional Municipality of Ottawa-Carleton

CRA

1801-16/06/87-D-0

HAZARD AND OPERABILITY STUDIES AT CHIPMAN CHEMICAL PLANT

by

W.D. Compton, Works Engineer, Chipman Business Unit, Canadian Industries Ltd., Stoney Creek, Ontario

In any project there exists three fundamental requirements, namely, that work be done on time, within budget and that the plant do what is required of it safely. Traditionally, great emphasis has been placed on cost and schedule control. Hazard and Operability Studies allow for employee involvement and ensure that safety is also given high priority.

C-I-L's Policy of Responsible Care requires the use of Haz-Ops to identify and correct potential safety problems before they occur.

Although it is recognised that Haz-Ops add to project and operating costs, both through increased manpower involvement and from the inevitable equipment enhancements that result from Hazard Studies, C-I-L believe this to be a good investment with an acceptable payback.

A Hazard and Operability Study is undertaken by a multidiscipline team, carefully chosen to provide the necessary knowledge and experience in the process details. Typically, it would include management, supervision, employee and Health and Safety Committee representation.

A person experienced in Haz-Op Studies and trained in the leadership role guides the team using a systematic approach. Several check lists are available which help to provide structure to the sessions and ensure that obvious hazards are identified. These, however, are only guides and the leader must use his skill and judgement to direct questioning beyond these lists to expose other potential hazards.

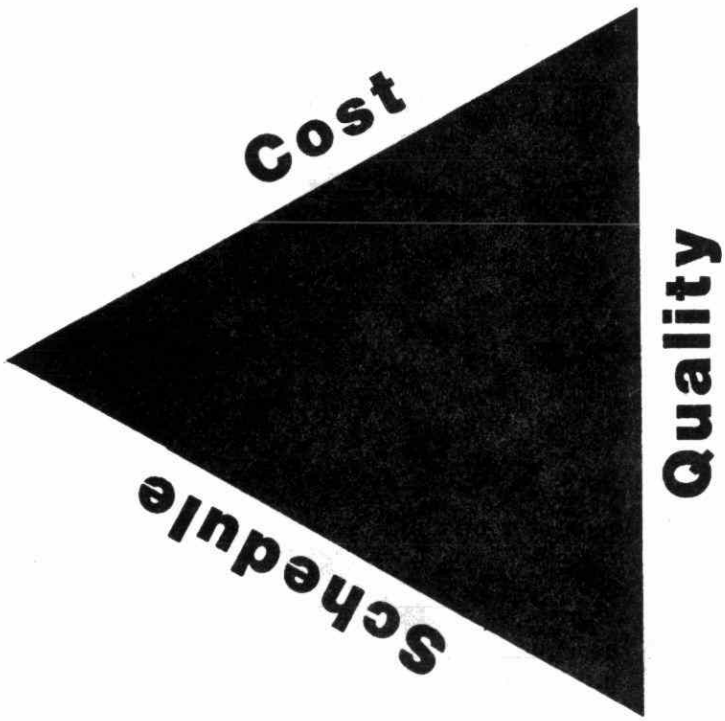
Haz-Op studies are done through meetings and/or plant visits. Documentation used includes flow sheets, interlock schedules, material data sheets, general arrangement drawings and operating instructions. When reviewing an existing plant, it is essential that these drawings represent the as-built condition of the plant.

Haz-Ops are undertaken from conceptual process development through to plant operation and ultimately plant demolition.

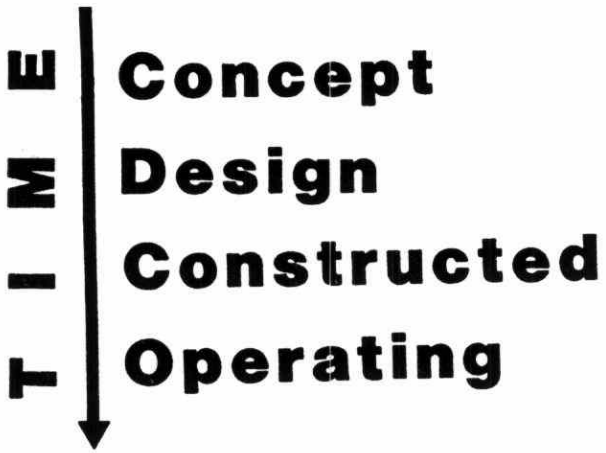
Hazard and Operability Studies use several approaches to hazard identification. One is to look for likely occurrences of a major hazard such as fire, explosion or spill. Another is to consider what hazards could occur with deviations from normal plant operation e.g. incorrect order of ingredient addition, high pressure, reverse flow.

The hazards identified are recorded and target dates and responsibilities assigned for completion of corrective action. It is important to note that while designers are usually included in the Haz-Op team, the purpose of the Haz-Op is to identify hazards. It remains the duty of the designers to consider the hazards identified and propose solutions which in turn are subject to further Haz-Op review. Management's role is to ensure that agreement is reached.

HAZARD AND OPERABILITY STUDY at


Cost
Quality
Schedule

- Team
- Leader
- Documentation
- Meetings/plant tours
- Systematic approach


TIME
Concept
Design
Constructed
Operating

- Major hazards
- Parameter variation
- Plant inspection

- Team identifies problem
- Designers propose solution
- Team reviews solution
- Management endorses

DEVELOPMENT OF A STRATEGY FOR REHABILITATION OF HAMILTON HARBOUR

by

G.K. Rodgers, National Water Research Institute, Environment Canada, Canada Centre for Inland Waters, Burlington, Ontario

Most of the water and sediment quality problems associated with Hamilton Harbour have been known for some time. The fact that the waters violated provincial water quality objectives was reported to the International Joint Commission in 1970. The principal cause of these conditions was identified.

Remedial programs for municipal and industrial point sources were initiated and considerable progress has been made for problems associated with conventional pollutants and heavy metals. Over $250 million has been invested in these improvements to date.

Concurrently, investigations of conditions in the harbour have developed a much better understanding of how new point source controls will impact upon the harbour. Of significance are the studies that have explained the large impact of the exchange of water between Lake Ontario and the harbour; on water quality. There has been clarification of the extent and cause of widespread depletion of oxygen in the bottom waters in the summer months and the potential for fisheries rehabilitation. Considerable uncertainty, however, remains regarding the potential impact of the contaminated sediments.

While improvements in water quality have been documented, and waste loadings have been reduced some water quality objectives are still not being met in the Harbour itself.

The Great Lakes Water Quality Board of the International Joint Commission, to whom progress is reported regularly, has noted that in this location and 41 other locations around the Great Lakes

that detailed documented plans are needed to achieve both water quality and related beneficial uses. The jurisdictions have responded by establishing interagency teams of scientists and engineers whose job it is to develop specific plans by which the goals can be achieved. They have also been directed to develop these plans in consultation with the public, and with the many local and regional agencies who have a stake in the program and the improvements.

The first full report of the RAP Team for Hamilton Harbour is due at the end of 1987. Early 1988 will be the period when final public consultations will take place and agencies will be identifying their contributions to the plan. Both national and international reviews of the plan are scheduled.

Current Status and Improvements

Substantial reductions of contaminant loadings have taken place. Between 1980 and 1986 alone, the municipal sewage treatment plant programs have given rise to a 50% reduction in the total loadings of phosphorus to the Harbour. Treatment in these same plants has resulted in a steady reduction in fecal coliform bacteria counts in the harbour since 1975. Industrial waste loadings for the conventional pollutants have been reduced by 74 to 94% between 1967 and 1985 (Table 1).

Parameter	1967 (kg/d)	1983 (kg/d)	% Reduction
BOD_5	33,000	4,300	86
Suspended Solids	150,000	25,000	83
Phosphorus as P	1,200	85	93
Ammonia as N	24,000	1,480	94
Cyanide as Cn	700	197	72
Phenolics	1,200	95	92
Solvent Extractables	25,000	1,480	94

Ref. Hamilton Harbour Technical Summary, August, 1985, OMOE.

Improvements in water quality have been noted as a result of these programs. While some responses in the Harbour are direct, others lag. This is, in part, the result of the reservoir of materials in the harbour sediments which are still active.

Nonetheless, the water quality changes that have been noted, along with the observation that there are over 50 species of fish found in the harbour, are positive signs that useful progress can be made in rehabilitating the system.

There is, however, no question of restoring the Harbour to its pre-industrial state. It has been severely stressed for too many years to consider restoring the Bay to a pristine condition. But we are convinced that more enhanced beneficial uses can be realized. Further point-source controls are necessary but will not be sufficient in themselves to realize our goals. Urban and rural runoff are important contributors to the problem.

Contaminated Sediments

The factors that have to be addressed go well beyond the customary concerns for point source controls or straightforward water

quality standards. First, there remains in the bottom of the Harbour the legacy of contaminant loadings from many years past. Once the sources of all significant metal and trace organic contaminants have been controlled (and many already have been), consideration will have to be given to how to address this problem.

For one visible segment of the contaminated sediment problem in Windermere Basin, dredging has been selected as the best option. Final details of the dredging plan are now being drawn up.

Maintenance dredging for navigation is still required in the Harbour. And the dredged material has to be put in to confined disposal facilities. However, because the contaminant content of harbour sediments exceed guidelines the existing facilities for this storage have a capacity adequate only to the year 2000.

But the strategy for the remainder of the contaminated sediment in the harbour is not clear. A major objective of field investigations this summer is the development of sufficient new information about the sediment characteristics that we may be able to judge whether removal, treatment inplace or burial are required. Although the details differ from one harbour to another, this general problem is common to 39 of the 42 Areas of Concern for which RAP's have to be developed. There is no standard manual available to look up the solution, and many of the cures being proposed have as uncertain an environmental impact as the original 'complaint'. There is a great deal of room here for innovative, but carefully assessed methods of judging the degree of hazard these sediments present and the impact of potential remedial measures.

Fish and Wildlife Habitat

Close on the heels of the problem of contaminated sediments. is the question of enhancement of suitable fish and wildlife habitat. One of the most dramatic impacts of development on the harbour has been the elimination of marsh and suitable shore zones for biota. Mud has buried sand and gravel spawning beds, and clogged marsh areas that serve as breeding grounds for ducks and as shelter for juvenile fish. Vertical concrete walls and sheet pilings along developed shores have eliminated a large fraction of the habitat necessary to realize fish and wildlife objectives.

It has been suggested that destruction of habitat through development, through loss of marsh, or through siltation, may be the major limiting factor affecting both the abundance of fish and the re-establishment of a more desirable mix of fish species.

Suitable new habitat can be constructed, whether done specifically for development of new littoral zone, or done in the development of other projects. In modifying existing shore or in the development of recreational islands it is possible to grade offshore depths, delineate irregular shorelines or put in structures that will attract fish and thereby enhance the harbour fishery.

Some conflict arises where shore property owners are obliged to protect themselves from erosion during high water levels. In fact, water levels themselves are a major factor in the year-to-year variation of marsh development.

The marsh habitat in the Harbour and in the shallow areas that drain into the Harbour (Cootes Paradise and the Grindstone Creek

channel) has receded markedly in past decades. High water levels are implicated, but a much longer term deleterious trend seems to be indicated by the data. In this regard the siltation or reduction of light penetration due to suspended solids being discharged from the watershed has been suggested as a cause. Thirdly, the carp population, which is fairly large, is very destructive of marsh and beneficial weed beds. These factors will have to be carefully assessed.

Erosion in the watershed is a widespread problem. Some of the material originates in new urban developments, some in rural areas. Enhanced erosion in naturally erodable materials has probably been due to increases in the peak of the storm hydrographs as the surface permeability has been reduced through land use development. Critical areas of the watershed where the majority of eroded material originates can be identified. These are being investigated with a view to remediation.

Some contaminant loadings particularly phosphorus, are associated with the suspended sediment in this runoff. It would appear that a control program for suspended sediment loadings would bring additional benefits in the more ecologically sensitive estuaries of the inflowing streams.

It would seem in these last two sections that we have gone far afield of the usual water quality concerns. These are necessary in order to address the more comprehensive objective of rejuvenating a complete and a more useful aquatic ecosystem. But the industrial and municipal point sources still present an important element in the program.

Municipal STP effluent remediation for nutrients & ammonia

Ammonia treatment and phosphorus removal are linked in an effort to bring under control the highly enriched state of the Harbour and the associated low oxygen levels in the hypolimnion of the summer months. While primary productivity levels are apparently limited by conditions other than just nutrient levels in the Harbour, both this productivity at the time of its decomposition, and the direct oxygen demand of the ammonia are implicated in the deoxygenation of the hypolimnion. Nitrification is being evaluated at the Hamilton STP as one step in this program.

Further reductions in phosphorus loadings from STP's seem feasible technically, though consistent reductions to 0.1 mg/l P in the effluents, which seem to be required to achieve the very best trophic conditions for the Harbour, will be a major developmental step for such plants in Ontario.

In the programs for N and P remediation, care will have to be taken to stage reductions in such a way that the N/P ratio is maintained or increased. This is to avoid the growth of the less acceptable blue-green algae. In all these programs, we will be required to consider several characteristics within the trophic state to attempt to plot a course which leads to healthier plant growth, both in reduced abundance and in species composition.

Like many cities, Hamilton is facing difficulties arising from combined sewer overflows. The city essentially has a single sewer system. Severe rain storms occasionally overload the system however,

and the overflow discharges directly to the Harbour. This gives rise to a variety of contaminant loadings in addition to nutrients from domestic waste. The city has already embarked on a program to address this problem. They have made submissions to develop more sophisticated flow control systems (based on work at McMaster University) that will maximize contaminant treatment from both the storm sewers and the sanitary sewers. They have also embarked on a program to increase storage in the combined system that will substantially reduce the frequency of overflows.

Consideration has been given to the idea of diverting the waste effluent of both Hamilton and Burlington STP's directly to Lake Ontario, rather than to the Harbour (as happens at present). This would reduce loadings of ammonia and phosphorus to the Harbour by 87% and 73% respectively, meeting a large portion of the target loading reductions. The feasibility of this proposal hasn't been investigated intensively as yet, but the public and the public consultative group of stakeholders have expressed opposition to this option.

The Municipal and Industrial Strategy for Abatement (the MISA Program)

This new program of the province of Ontario has been presented elsewhere. Clearly it is prudent to reduce to the extent feasible the continual discharge of trace metal and trace organic contaminants before attempting to address the problem of the accumulated residues in the bottom sediments of the main Harbour. The Hamilton Harbour RAP will be depending heavily on the results of the municipal program and the iron and steel industry sector programs to address these

discharges if they prove to be major components of the current hazard from contaminated sediment, or of direct concern to water quality.

Direct Treatment of the Harbour

Although it is generally agreed that reduction of contaminants at source is the preferred strategy, rehabilitation of the Harbour may require direct treatment during summer months for the low dissolved oxygen in the hypolimnion at least for some initial period. Lakes that have received high loadings for many years have often been found to recover slowly. In these cases the recovery process may be expedited by temporary direct treatment.

For this reason, pilot studies of direct treatment by oxidation are being carried out. This treatment potentially carries benefits additional to relief of the temporary, but very low oxygen condition that occurs. The mobility of toxic metals in the sediments is enhanced by anoxia. Maintaining oxidized water would reduce the movement of metals from the sediment to the water column, enhance bacterial degradation of some organic contaminants and improve habitat for the Harbour fishery.

Iron additions have the consequence of the iron and steel industry in the harbour. The lack of phosphorus release from Harbour sediments is probably a reflection of this. Hence future iron releases may have to be judged from both potential hazard and benefit.

Other chemical treatments such as lime or nitrate injection are also being considered, as is the potential for physical sealing of the sediment.

Public Consultation

Two public consultation processes have been employed. Public meetings for the general population of the watershed have been held at regular intervals to present information, hear briefs and answer questions. The views expressed in these meetings are documented and considered by the writing Team and the Stakeholders.

The Stakeholders group is made up of agencies, organizations, government departments, industries and private citizen groups who either make use of the Harbour, who wish to make use of the Harbour, or who have some jurisdiction over matters affecting water quality in this body of water. The membership of the Stakeholders for Hamilton Harbour numbers 40° at present. Many of the Stakeholders represent agencies or industries that will play a role in the implementation of the Remedial Plan.

The reports of the Stakeholders group to the provincial and federal governments are formal, and have represented an extensive analysis of the work of the team of experts. The Stakeholders have reviewed information about conditions in the Harbour and have recommended the beneficial uses which they would like to see enhanced or reestablished in the Harbour through the Remedial Plan. This group also reviews related issues such as public access to the Harbour, various developments and policies which have a bearing on the use of the Harbour and aesthetic conditions that go beyond water quality itself, but do affect the enjoyment and image of the Harbour.

Summary

The federal and provincial governments, in response to the Great Lakes Water Quality Board, have undertaken to develop Remedial Action Plans for the 17 Areas of Concern within Canadian jurisdiction. Hamilton Harbour is one of the major sites for which a plan is required. By early 1988, a plan and strategy (with options) will be presented by the multi-agency technical team charged with this responsibility. Their report will detail:

(i) conditions in the Harbour

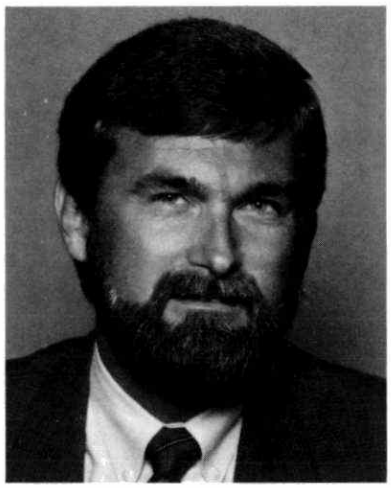
(ii) remedial options, their costs benefits and likely impact

(iii) potential schedule for implementation, and

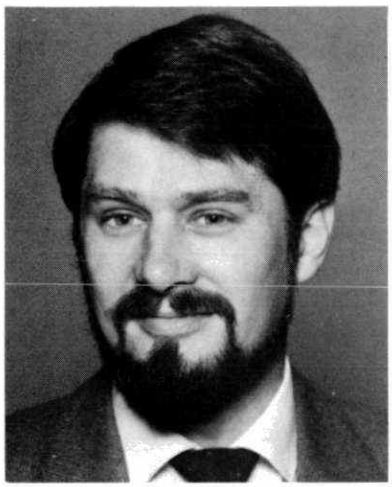
(iv) a monitoring plan

Following this presentation and its review by the public, governments will respond with the final schedule.

Comprehensive rehabilitation schemes such as are being attempted in these Areas of Concern are not numerous. In many respects the plan will be experimental, and flexibility will be essential in its implementation.



Moderator: D. Guscott, Director
Southeastern Region
Environment Ontario, Kingston



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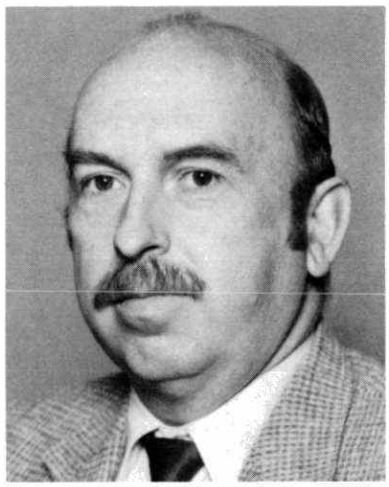

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NEW WASTE MANAGEMENT INITIATIVES

by

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Mr. Breeze spoke from notes at the Conference and did not make available a text of his paper for inclusion in the Conference Proceedings at the time of publication.

For those who are interested in the Ministry's new waste management initiatives, it is suggested that they contact Mr. Breeze direct at the Ministry Waste Management Branch, 5th Floor, 40 St. Clair Ave.,West, Toronto, Ontario M4V 1M2 - Telephone - 323-5211.

MUNICIPAL/INDUSTRIAL WASTE REDUCTION PROGRAM

by

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Introduction

The Ontario Ministry of the Environment has had programs to support planning and implementation of improved municipal waste management systems since the mid 1970's. Many of these early efforts to encourage development of alternatives to disposal of wastes were not accepted by municipal decision makers because of the technical and economic risks with emerging waste management technology. Early disappointments with some technologies fostered a continuing cautious approach to most alternatives to disposal. Unfortunately, many of these alternatives that offered legitimate opportunity were dismissed with the "gold in garbage" myth.

Municipal waste diversion from disposal by the early 1980's was limited to a few recycling projects operated by non-profit groups and a few municipalities. Diversion of the municipal waste from disposal was less than one per cent of the residential waste stream. Industrial recycling was well established through secondary material dealers and brokers for certain materials such as ferrous and non-ferrous scrap metals and some secondary fibres. Most of these materials were available from selected sources but there remained large volumes of materials in the industrial waste stream that had not been tapped and that continued to be disposed. In Ontario, it is estimated that approximately one half of the wastes disposed in landfills is from industrial and commercial sources.

In 1981, the Ministry of the Environment announced a Source Separation Program to support municipal recycling efforts. The opening of the Ontario Paper Company's newspaper de-inking plant in 1982 helped significantly in the growth of municipal recycling by providing a large stable market compared to the preceding years.

The application of the Environmental Assessment Act to municipal projects provided a further impetus to the development of municipal waste management alternatives.

The Blueprint for Waste Management in Ontario in 1983 further focused attention on regulatory and program changes needed to ensure the development of environmentally sound waste management systems. The 4Rs of waste management, reduction, reuse, recycling and recovery, received wide spread support in principle.

Reduction, Reuse, Recycling and Recovery (4Rs)

Definition of the 4Rs as used here will assist in the distinction between these alternatives to disposal.

Reduction means the lowering of the rate of waste production. For municipal wastes, this would require altering consumer buying habits and lifestyle. For industrial wastes this could involve changes to processes, improved housekeeping, or more careful control of process inputs and outputs.

Reuse is the use of a waste material again in its original form. Refillable bottles are examples for municipal wastes. Wooden pallets represent a common industrial example. Both reduction and reuse involve the waste generator and, if effectively applied, can result in no waste for disposal for specific cases.

Recycling is the handling and use of materials that have been kept separate as distinct materials for subsequent collection

and shipment to a customer. The material need not be used in the same product as the original material but it must be consciously sorted at the point of generation to keep contaminants to a minimum to ensure industry specifications are met.

Recovery is the processing and use of materials (or energy) that have been separated (or produced) from the mixed waste stream. Compost and refuse derived fuel are municipal examples. The sorting of commercial/industrial waste for corrugated cardboard is an industrial example.

Both recycling and recovery schemes are used after the waste generator has no further beneficial use for the waste. Reduction and reuse strategies are applicable to both municipal and industrial sectors but are expected to be applied more by industry than the general public. Cost conscious industry is more likely to adopt reduction and reuse strategies than the general public which has had less incentive to be cost conscious of its waste.

Recycling has received overwhelming support by the public as evidenced by project participation rates exceeding eighty per cent in most communities providing the opportunity to participate in multi-material curbside projects. In 1986-87, the Ministry provided almost $4 million to support the continued expansion and operation of municipal recycling

projects through the Municipal Recycling Support Program, an enhanced version of the earlier Source Separation Program. This funding support continues from the Ministry for recycling and new support is available through Ontario Multi-Material Recycling Inc. (OMMRI). This non profit corporation represents industries involved in the production, distribution, and retailing of carbonated soft drink beverages in Ontario. The combined support from the Province and industry is rapidly developing a municipal recycling infrastructure to help the soft drink industry achieve their goal to satisfy Ontario's beverage container regulations and municipalities to divert waste from disposal by recycling approximately fifteen per cent of the municipal waste stream.

Ontario Ministry of the Environment 4R Programs

In June 1986, the Waste Management Branch of the Ministry was restructured to provide a section devoted to encouraging 4Rs initiatives. The Waste Reduction Section includes a Municipal Program Unit, an Industrial Program Unit, and a Market Development and Promotion Unit as support for the other two units. The new Waste Reduction Section has developed the 4R components of the Ministry's Comprehensive Waste Management Funding Program and will be administering the municipal and industrial support programs available.

The 4R program component of the Comprehensive Funding Program includes new municipal programs to support reduction, reuse, and recovery efforts to round out the existing support available to municipalities through the Municipal Recycling Support Program for recycling. The industrial 4R program is completely new and is the primary focus of this paper but first a review of the new municipal initiatives is presented.

Municipal 4R Program

The municipal 4R program provides support in addition to that existing through the Municipal Recycling Support Program. Financial and technical assistance are available for new reduction, reuse, and recovery efforts to further minimize the quantity of waste for disposal.

The municipal reduction and reuse program components are directed at the consumer or waste generator level to attempt to alter behaviour through greater awareness of individual responsibility to lessen the production of waste in the first place. Capital, promotional, and educational costs are eligible for assistance. While some immediate benefits can be achieved, the impact of waste reduction and reuse efforts are viewed as having greater long term benefits.

The municipal recovery program component provides capital support for material recovery from the mixed waste stream. Such material recovery projects will deal with the mixed waste stream after reduction, reuse, and recycling efforts have been exhausted. Up to 80% of the waste stream that would otherwise be disposed can be recovered for use by industry or municipalities. Compost, papers, metals, plastics, and refuse derived fuel are examples of recoverable commodities.

A greater lead time is required to develop municipal waste recovery projects than recycling projects. Such projects are being reviewed as alternatives to disposal in the Waste Management Master Plan studies currently in progress in twenty seven study areas covering the most densely populated communities in Ontario. Implementation of recovery projects is expected to experience lag time that was also seen in development of recycling projects. With the current growth in recycling, it appears some of the first material recovery projects would likely be coming into operation when the growth of municipal recycling has peaked both in numbers of municipalities participating and the diversion impact on the waste stream. The ongoing development of recovery projects can sustain the growth of waste diversion from disposal that has been started through recycling. Ministry market development efforts in the past have assisted industry in having the necessary facts and experience to make the

commitment to become a partner in municipal waste management. Long term projections are that between thirty and fifty per cent of the municipal waste stream can be diverted from disposal by effective use of the 4Rs.

Industrial 4Rs Program

Through discussions with all sectors concerned with the future of waste management, it became clear that industrial waste, both hazardous and non-hazardous, offered similar potential for diversion of waste requiring disposal. Increasingly stringent legislation has been introduced to correct practices that have been found to be environmentally unacceptable as more knowledge is gained on waste management. This trend will continue as we steadily learn more and as the public demands more environmentally sound waste management systems.

The new Industrial Program Unit in the Waste Management Branch was formed to assist industry in developing the full potential of the 4Rs for industrial wastes. The focus of the unit's activities is to make industry more aware of the 4R opportunities that are available and to provide financial and technical assistance to ensure the timely implementation of 4R approaches. Ministry financial assistance will help to

reduce the costs and risks that industry faces in shifting to more environmentally sound waste management practices required by new legislation such as Regulation 309 already in place and future legislation more tightly controlling waste-water (MISA) and air emissions (revised Regulation 308).

The following are the key initiatives of the new Industrial Program Unit in fulfilling its mandate.

Information/Education

The unit will develop and maintain liaison with a wide range of industrial associations, interest groups, municipalities, other provincial ministries and agencies, and other jurisdictions to ensure that the latest developments can be brought to the attention of Ontario industry. Ministry Regional and District office staff who deal directly with industry on a day to day regulatory basis will be part of the Ministry team identifying 4R opportunities and assisting industry in their development.

Ontario Waste Management Corporation

Ministry of the Environment and Ontario Waste Management

Corporation (OWMC) staff are working together to achieve 4Rs goals with Ontario's industry. The OWMC's mandate is targetted to hazardous and liquid industrial wastes. The Ministry's 4R efforts will include these wastes as well as non-hazardous solid wastes, which now are disposed in municipal landfills. Liaison between the two agencies which both have daily contact with industry will ensure that the capabilities and programs of each agency are conveyed to industry. The library and laboratory facilities of OWMC offer services to industry to help solve their problems.

Waste Exchanges

The Ministry of the Environment provides financial assistance for both the Canadian Waste Materials Exchange and the Ontario Waste Exchange. The Ontario Waste Exchange is jointly supported by the OWMC and, for the first time this year, by the Ministry of the Environment. Both exchanges are operated through the Ontario Research Foundation and share the same listings. With the support from the Ministry of the Environment and OWMC, the Ontario Waste Exchange has been able to obtain a full-time staff member to actively pursue listings and effect exchanges. Until this full-time staff member was hired, the Ontario Waste Materials Exchange operated in a similar passive mode as the Canadian Waste Exchange. The full-time staff member reviews contacts on listings that do not result

in an exchange to determine the barriers to a successful exchange and whether further initiatives can be taken to eventually effect more exchanges. The Canadian Waste Materials Exchange achieved an estimated transfer of 280,000 tonnes of material in 1986 with a replacement value of approximately $10.5 million. Approximately 70% of the Canadian Waste Materials Exchange transactions occur in Ontario and it is anticipated that the enhanced Ontario Waste Exchange will significantly improve this impressive performance.

Industrial 4Rs Support Program

The Industrial Program Unit has developed a support program which is a part of the Comprehensive Waste Management Funding Program announced in the Throne Speech in April, 1987. Details of this new program to assist industry to implement industrial 4R activities follow.

Assistance

Assistance available to industry includes information, technical advice and financial support for both capital and start-up costs. Assistance for seminars or workshops on 4Rs will be considered on a case-by-case basis.

Eligibility

Proponents eligible for assistance include all industrial and commercial sectors. Consulting firms involved in industrial 4R work may also apply, whether or not the application is on behalf of a specific industry. Municipal proponents or their contractor are not eligible but would be eligible under the municipal program initiatives.

Projects eligible for assistance include feasibility studies, the implementation of new or expanded projects for the reduction, reuse, recycling and recovery of wastes, process or equipment modification or evaluation or both, demonstration of technology either new to Ontario or novel to industry, upgrading operations beyond current state-of-the-art, and research. The focus of the program will be to support projects that break new ground or reduce risks in the implementation of the 4Rs. Projects which merely duplicate common industry practices that can be readily implemented will be less likely to receive support, if any at all.

Costs eligible for support include capital costs, start-up or commissioning costs for a defined time period, demonstration costs, and research. Costs for land or its servicing, licences, patents, and royalties are not eligible for support.

Demonstrations of a technology or process and research may receive up to 100% of the eligible costs. These activities will normally be viewed as short term projects and a defined time period to achieve the results will be expected as part of the proponent's application.

Capital costs for projects will be supported up to a maximum of 50% of the total projected eligible costs but Ministry support will not exceed a proponent's equity in the project.

Start-up or commissioning costs also will be supported up to a maximum of 50% but for a period of time consistent with the scope of the project. Normally such assistance would not exceed six months.

Proposal Evaluation Criteria

The Industrial Program Unit staff, with support from other Ministry staff if required, will evaluate proposals on a first come first served basis for full or partial funding to the levels already identified. Criteria that will be used include the elimination or reduction of contaminants of environmental concern, the quantity impact on the waste stream, the scope of the proposal with respect to the potential for further application in Ontario, cost/benefit

analysis, the capability of the proponent to undertake the project (technical and business competence) and the export potential for Ontario industry of new technology. The Ministry's budget will also be a factor in decisions on proposals but every effort will be made to provide support that leads to the fullest implementation of the industrial 4Rs to divert waste from disposal in an environmentally sound manner.

The Industrial 4Rs Program as outlined is a start to further improving the management of industrial wastes in Ontario. The Ministry is open to suggestions on how this program can be improved.

Staff of the Industrial Program Unit will be monitoring the results achieved and identifying, through discussions with industry, changes that may be needed to better satisfy industry's needs or to address needs that are not specifically included now. Ministry staff will endeavour to make appropriate revisions to the program to provide sufficient support to assist Ontario industry to develop models of industrial waste reduction, reuse, recycling and recovery initiatives that will ensure environmentally sound waste systems are available now and for the future.

A SUCCESSFUL REGIONAL PROGRAM TO ASSIST IN INDUSTRIAL WASTE REDUCTION

by

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Municipality of Peel, Brampton, Ontario

1) Introduction:

The Regional Municipality of Peel became involved in Industrial Waste Reduction when Regional Council committed to reduce the total waste directed to Regional landfills 54% by the year 1990. A target of 23% of this reduction is to occur through recycling and reduction practices and the rest through an energy-from-waste program. This 23% diversion of waste is to be achieved with 13% coming from the Industrial and Commercial sector and 10% from the Municipal waste streams. An important point to note is that this reduction of waste is from the total waste generated within the Region.

2) The Problem:

The Region currently operates three landfill sites located within the Municipality. In 1986 there was 685,085 tonnes of waste landfilled, of which 421,372 tonnes was generated by the Industrial and Commercial sector. Much of that waste was produced in large continuous quantities which facilitates an easier segregation of waste than can be achieved with the municipal waste stream. Currently the Region will run out of landfill space by 1992, thus a current search for new landfill capacity is being undertaken. The new site will have a life expectancy of 40 years. If there is no reduction in the amount of waste projected to be landfilled, a total of 1,222 acres will be required, if however, the waste will be reduced as Council has agreed, only 530 acres will be required.

By 1990 the total tonnage of waste projected to be produced in Peel is 787,000 tonnes. With the reduction goals we expect that 56,250 tonnes will be recycled by the Industrial sector at that time.

3) a) Program Development:

The concept of an Industrial Waste Reduction Program was conceived in the preparations leading into the 1985 Current Budget cycle. The inclusion of this program into the budget demonstrated Council's commitment to obtain the waste reduction goals. The program began in October, 1985, with the introduction of a program co-ordinator.

3) a) Program Development - Cont.

The Industrial Reduction Program was designed to be an active program. The Co-ordinator is responsible for working with Industry to:

1) Suggest methods to reduce waste requiring landfilling.

2) Actively seek and promote markets for waste materials.

3) Meet with Industry, Trade and Business Associations to provide information and assistance for their members.

4) Perform Waste Audits and operate a waste exchange.

5) Provide Educational programs and opportunities for Industry.

6) Provide technical information and assistance.

7) Develop promotional programs.

In order to accomplish the above, the Co-ordinator must work with Industry through close personal contact and be willing to ensure confidentiality to build a trusting relationship.

3) bi) Initial Steps:

The Program Co-ordinator undertook a series of steps designed to introduce the program and explain its purpose. An information package was assembled and forwarded to trade groups such as the Area Boards of Trade, Industrial Associations, The Ontario Waste Management Association, and the MOE. Introductory packages were then forwarded to Industry Representatives and were intended to provide instructions on how to use the program as well as describe the goals and how they would be met. The packages were followed by a telephone call or visit to meet the executive. This effort provided an enormous amount of creditability to the program and allowed an opportunity for discussion with people of various backgrounds, all of whom had an interest in the program goals. This was very valuable in defining the scope of the program and refining the aims and objectives as well as providing insite into the problems faced by Industry.

3) bii) Plant Visits:

Waste Audits were undertaken at a regular basis to further uncover both new waste materials with the potential to be directed away from landfill, as well as previously unknown markets for waste materials. The initial plant visits were made to evaluate the intended approach, to make improvements where necessary, and to uncover pitfalls in the evaluation process. During these plant visits the waste audit was completed where each waste stream, its characteristics, quantity, quality, and current means of handling and disposal were recorded. The information was then used in the evaluation process to make recommendations to reduce the amount of waste generated or for its recycling. This information was also used to establish the waste materials exchange listing.

biii) Regional Waste Survey:

In the efforts to identify the greatest potential volume of waste that might be recycled a number of avenues were followed.

1) landfill spot checks
2) reviewing special requests to landfill questionable materials
3) involvement of the Waste & Water Pollution Control Section, Waste Management Division in their plant visits
4) involve the waste haulers
5) direct queries from Industries
6) perform a Regional Solid Waste Survey

The first five items were relatively straight forward and are maintained without much effort. The sixth item required a special effort. This involved sampling at random and performing a waste audit of a small number of businesses from each Industrial Classification as maintained by the Region.

The Region maintains records of the 7,500 companies located within the municipality through yearly plant visits performed by the Inspectors of the Waste & Water Pollution Control Section of the Waste Management Division. The results of this survey was used in order to target on specific types of materials that could be recycled as well as providing a wide overview as to the waste that is generated within the Region.

3) c) Investigating Alternatives To Disposal:

In general terms, alternatives to disposal followed the 4R's approach - reduction, reuse, recycling and reclamation. Where reduction of wastes was not permitted, the search began for markets for the reuse or recycling of that material.

The Region of Peel is in an ideal location in terms of proximity of recycling industries. This is an industry sector all in itself and includes businesses that recycle asphalt and concrete, drums, glass, metal, oil, paper products, plastics, solvents and textiles. The information on file with the Waste Management Division on the markets for waste materials was reviewed and updated where necessary. The Co-ordinator then undertook to add to this information by making as many contacts as possible and personally visiting the spokesperson. These visits ensured that a thorough understanding of the types of materials and the particular needs of the markets were understood as well as establishing, once again, the creditability required to work within these markets. Examples of the types of organizations approached include:

1) Third World Relief agencies for potential use of redundant drugs and foods, as well as surplus goods.
2) Non-Profit Organizations such as the Salvation Army and Lions Clubs.
3) Waste Processing Companies.
4) Manufacturers with the potential to use different grades of waste materials as raw product in their production process.
5) Import and Export Companies.
6) Recyclers of different materials.

All of this work resulted in the completion of a manual known as the Industrial Waste Recycling and Disposal Directory which was placed on computer and can be easily updated. This directory was then distributed to as many potential users as possible to encourage feedback on its layout and effectiveness.

3) c) Investigation Alternatives To Disposal - Cont.

Waste Materials that do not have established markets such as glass and cardboard can still be diverted from landfill. It is necessary to clearly understand the material properties and the quantities produced. Through the use of reference information on chemicals such as the Merck Index and Kirk & Ottmeir volumes and the 'Made in Ontario' 1986 Book for materials, waste can be recycled to be used in different production processes. The use of these references requires some amount of time and effort but the rewards generated can more than make up for time spent.

A Regional Waste Materials Exchange program was developed to advertise the availability of those materials that the Co-ordinator could not quickly divert from landfill. This program resulted in many specific inquiries from interested businesses that might use a listed material.

4) Specific Market Potential:

Industry quickly made us aware of their two main motives to become involved in Industrial Waste Reduction programs.

1) Profit

2) Legislation

In order to have a successful relationship with Industry it is important to rely on the profit motive. The businessman wants to know where he can either save or make money. Therefore the Region has engaged in serious discussions with a number of businessmen in order to promote the Region as a place to establish a business that relies on waste as a raw product. Unfortunately this is a long process which requires much effort. Examples of the types of discussions entered into to date include:

a) The use of wood waste by companies that would produce densified products or wood laminates.

b) The use of organic - nontoxic waste in a soil enrichment program.

4) Specific Market Potential - Cont.

c) Establishment of construction waste depots to transfer this type of waste for clean fill projects, such as quarry rehabilitation.

d) The use of organic sludge as animal feed.

To assist in these efforts we have undertaken surveys and produced maps indicating sources of particular waste material within the Region. We have also placed industry in contact with specialized consultants to discuss specific processes.

Legislation is an effective means of motivating Industry to reveiw their operations. We have been told on many occasions that operations would change if there was legislation enacted to force it. At the Municipal level there is little that can be done other than the enactment of Municipal Bylaws. We are looking at various policies that the Region could develop to reduce the amount of waste generated. Some of these are:

1) Restrict the entry to the Britannia Sanitary Landfill Site of designated recyclable materials.

2) Imposing a surcharge on recyclable material similar to a sewer surcharge.

3) Assist private industry to initiate recycling programs.

4) Provide a diversion credit to industries or to volunteer groups servicing industries.

5) Restrict the entry to landfill of materials until it has been shown that the material cannot be recycled.

6) Construction of waste collection and sorting facilities that would be operated by the Region.

7) Provision of bin areas for receiving recyclable material.

8) Raise the landfill tipping fee.

Several of the above points can be combined in the profit and legislative motives. The Region has decided to follow through and raise the landfill tipping fee. We expect greater co-operation now from Industry as it has now become more economical to recycle.

5) Education and Promotion:

The key to the success of any new program is the education and promotion efforts that are enacted. Our efforts to date have been in the items listed, they have been proven to be quite effective and plans to expand on these initial efforts are being made.

a) Education - Provision of Information related to:

- The Provincial 4R's
- Federal and Provincial recycling and assistance programs
- Prices and trends for recycled materials
- Available technologies and services (ie: consulting engineers, hauling companies, different treatment technologies)
- Regional waste material exchange
- Industrial Waste Disposal and Recycling Directory
- Proper waste audit procedures and good housekeeping practices

b) Promotion is Achieved by:

- Operation of a waste hotline known as the "WASTELINE" to provide information and receive comments.
- Promotion of a Recycler Award of Merit in the Region to be awarded to industries demonstrating unprecedented commitment to waste reduction.
- Preparation of newsletters and talks to businesses, haulers, industrial and trade associations along with active participation on various committees and presentations at various Trade Shows.
- Distribution of program information by Waste Management Division Inspectors.

7) Program Successes and Future Direction:

Success can be measured by many different yard sticks. In the first year of operation there were over 450 contacts with businesses with approximately 100 successful exchanges which resulted in a percentage of successful exchanges of approximately 20%. Another is to look at the total tonnage recycled, which in 1986 amounted to 11,940 tonnes, and included materials such as shown below. A third is the cost of the program of which in the first year ranged between $6.00 and $7.00 per tonne

Material Diverted/Exchanged	Receiver
ammonium bicarbonate	via chemical brokers
silica gel	flower driers
calcium carbonate	farmers
sodium dichromate	tanneries
pharmaceutical glass containers	glass reclaimers
medical supplies (enema kits)	third world associations
wood wastes	local firewood receivers
off spec dairy products	pig farmers
food grade pharmaceutical starch	pig farmers
cardboard	corrugated recyclers
packaging foam	sewing supplies manufacturers
fruit flavoured drink	various non-profit organizations

The program has been considered to be an overwhelming success with everyone involved agreeing that it is worthwhile. However the program needs to become much more effective in order to meet the goal of a 13% reduction in wastes. The tonnage that is targeted for 1987 is 24,000 tonnes and by 1990 it is expected that 56,250 tonnes will be diverted from Regional landfills. The program is not expected to change from its initial thrusts, but it is anticipated that there will be more emphasis placed on the creation of new markets to use the materials.

RESULTS OF A COOPERATIVE STUDY OF TWELVE TEST METHODS FOR SOLIDIFIED WASTE CHARACTERIZATION

by

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THE SUBJECT OF MY TALK TODAY IS THE RESULTS FROM A COOPERATIVE EXPERIMENTAL PROGRAM, WHICH HAS BEEN ON-GOING FOR THE LAST THREE YEARS. IT IS OFFICIALLY ENTITLED "INVESTIGATION OF TEST METHODS FOR SOLIDIFIED WASTE CHARACTERIZATION"*.

SOLIDIFICATION PROCESSES ARE DESIGNED TO IMPROVE THE PHYSICAL AND CHEMICAL CHARACTERISTICS OF HAZARDOUS WASTES. A TYPICAL SOLIDIFIED WASTE MATRIX IS USUALLY FORMED FROM CEMENTING REACTIONS, SUCH AS THOSE IN PORTLAND CEMENT, OR POZZOLANIC REACTIONS, SUCH AS THOSE BETWEEN LIME AND FLY ASH. OTHER MATERIALS USED MAY INCLUDE CLAYS, POLYMERS OR PROPRIETARY SPECIALTY SORBENTS. THE CRUCIAL PROPERTIES OF THE MATRIX ARE ITS ABILITY TO HOLD CONTAMINANTS AND LOW PERMEABILITY TO GROUNDWATER.

THE COOPERATIVE PROGRAM HAD TWO MAIN OBJECTIVES: DIRECTLY, TO DETERMINE THE SUITABILITY OF TWELVE LABORATORY TEST METHODS FOR CHARACTERIZING THE PHYSICAL AND LEACHING PROPERTIES OF SOLIDIFIED WASTES, AND INDIRECTLY, TO DEVELOP A DATA BASE OF PROPERTIES OF SOLIDIFIED WASTES, ACHIEVABLE WITH PRESENT TECHNOLOGY. KNOWLEDGE OF THE RANGES OF VALUES OF THESE PROPERTIES WILL ASSIST REGULATORY AGENCIES IN SETTING GUIDELINES AND PROVIDE A BASIS FOR CONTINUED DEVELOPMENT OF TEST METHODS AND MATHEMATICAL MODELS.

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* THE MATERIAL PRESENTED HERE HAS BEEN PREVIOUSLY PUBLISHED (1, 2, 3), OR WILL BE PUBLISHED IN THE FINAL REPORT OF THIS STUDY, WHICH WILL BE AVAILABLE BY DECEMBER, 1987.

THE COOPERATIVE EFFORT INVOLVED ENVIRONMENT CANADA, THE UNITED STATES ENVIRONMENTAL PROTECTION AGENCY, ALBERTA ENVIRONMENT, THREE RESEARCH LABORATORIES IN THE UNITED STATES AND CANADA, AND FIFTEEN COMPANIES INVOLVED IN DEVELOPING OR MARKETING SOLIDIFICATION TECHNOLOGY. THESE COMPANIES INCLUDED FIVE CANADIAN COMPANIES, NINE AMERICAN, AND ONE DANISH.

THE PROGRAM WAS CONDUCTED AS FOLLOWS:
ENVIRONMENT CANADA AND US EPA PROVIDED THE FIFTEEN INDUSTRIAL PARTICIPANTS WITH SAMPLES OF THEIR CHOICE OF FIVE FULLY CHARACTERIZED UNTREATED HAZARDOUS WASTES. THE INDUSTRIAL PARTICIPANTS APPLIED THEIR PROPRIETARY PROCESSES TO THE WASTES AND RETURNED THE SOLIDIFIED SAMPLES TO THE LABORATORIES (ENVIRONMENT CANADA'S WASTEWATER TECHNOLOGY CENTRE, ALBERTA ENVIRONMENTAL CENTRE, AND US ARMY CORPS OF ENGINEERS' WATERWAYS EXPERIMENT STATION). INTERACTIONS BETWEEN THE LABS AND THE INDUSTRIAL PARTICIPANTS TOOK PLACE THROUGH THE ACTION OF A THIRD PARTY, WHO RANDOMIZED SAMPLES TO PREVENT THE TESTING LABORATORIES FROM KNOWING WHOSE SAMPLE THEY WERE TESTING. IN GENERAL, EACH OF THE 69 SOLIDIFIED PRODUCTS PRODUCED WAS TESTED IN DUPLICATE AT TWO OF THE THREE LABORATORIES.

THE FIVE WASTES USED IN THE STUDY (SEE SLIDE 1) WERE SELECTED TO INCLUDE BOTH WASTES WHICH ARE ROUTINELY SOLIDIFIED (A HEAVY METAL SOLUTION, DREDGE SPOILS, A PLATING WASTE, AND A HEAVY METAL SLUDGE), AND THOSE CONTAINING PROBLEM CONTAMINANTS (WOOD PRESERVATION WASTE CONTAMINATED SOIL, PHENOL IN THE SYNTHETIC SOLUTION). TWO SYNTHETIC WASTES WERE USED TO PROVIDE CONTINUITY WITH PREVIOUS INVESTIGATIONS CARRIED OUT AT THE WASTEWATER TECHNOLOGY CENTRE AND WATERWAYS EXPERIMENT STATION. THE FIRST WAS A 0.04 M SOLUTION OF HEAVY METALS AND PHENOL IN WATER, THE SECOND, A 20% SOLIDS METAL HYDROXIDE SLUDGE. THE THREE REAL WASTES WERE PROVIDED BY ANONYMOUS DONORS IN CANADA AND THE UNITED STATES.

RAW WASTES

		CONCENTRATION (PPM)
WTC SYNTHETIC SOLUTION	ARSENIC	2000
	CADMIUM	4500
	CHROMIUM	1500
	LEAD	8000
	PHENOL	3800
DREDGE SPOILS	CHROMIUM	500
	COPPER	100
	LEAD	200
	ZINC	2000
	MERCURY	0.7
	PCBs	7
ALUMINUM COIL PLATING WASTE	ALUMINUM	23000
	ARSENIC	20
	CHROMIUM	3000
	LEAD	50
	THALLIUM	20
	CYANIDE	2000
WOOD PRESERVATION WASTE SOIL	ARSENIC	80
	LEAD	70
	MERCURY	0.3
	PENTACHLOROPHENOL	10000
	PAHs	300
WES SYNTHETIC SLUDGE	CADMIUM	4500
	CHROMIUM	20000
	MERCURY	100
	NICKEL	20000

SLIDE 1

THE QUANTITIES OF CONTAMINANTS SHOWN FOR EACH WASTE ARE AVERAGES OF NINE ANALYSES. THE COEFFICIENTS OF VARIATION FOR THE DIFFERENT CONTAMINANTS RANGED FROM 10 TO 100%, REFLECTING ANALYTICAL VARIABILITY AND SAMPLE INHOMOGENEITY. MERCURY AND ARSENIC SHOWED THE MOST VARIABILITY. THE SYNTHETIC WASTES SHOWED THE LEAST VARIABILITY, PROBABLY BECAUSE THEY WERE THE MOST HOMOGENEOUS.

THE TEST METHODS INVESTIGATED WERE DESIGNED TO MEASURE THE INTRINSIC PHYSICAL AND CHEMICAL PROPERTIES OF SOLIDIFIED WASTES THAT AFFECT THEIR LEACHABILITY:

1) THE DEGREE OF CHEMICAL IMMOBILIZATION OF THE CONTAMINANTS, IE., THE CONTAMINANTS MAY BE CHEMICALLY BOUND IN A VARIETY OF COMPOUNDS OF VARYING SOLUBILITIES AND REACTIVITIES, OR THEY MAY BE PHYSICALLY ADSORBED OR TRAPPED IN THE SOLIDIFIED WASTE MATRIX. THE MECHANISM OF IMMOBILIZATION AFFECTS THE RESPONSE OF THE WASTE TO DIFFERENT GROUNDWATER CHARACTERISTICS, PARTICULARLY WITH REGARD TO pH AND REDOX POTENTIAL.

2) THE POTENTIAL FOR CONTACT OF THE GROUNDWATER WITH THE WASTE. THE HYDRAULIC CONDUCTIVITY OF A WASTE, AS WELL AS THAT OF ITS SURROUNDINGS, DETERMINES WHETHER MOBILE CONTAMINANTS ARE TRANSPORTED THROUGH THE WASTE MATRIX BY RAPID ADVECTION OR SLOW DIFFUSION. RESISTANCE TO WEATHERING, AND COMPRESSIVE STRENGTH MAY ALSO AFFECT THE SURFACE AREA OF WASTE IN CONTACT WITH THE GROUNDWATER.

NO ATTEMPT WAS MADE TO SIMULATE SITE-SPECIFIC DISPOSAL CONDITIONS. THE RESULTS FROM THE TEST METHODS ARE NOT INTENDED TO BE INTERPRETED DIRECTLY IN TERMS OF ENVIRONMENTAL IMPACT. RATHER, THE WASTE INTRINSIC PROPERTIES CAN BE USED IN CONJUNCTION WITH THE FIELD CONDITIONS TO INFER ENVIRONMENTAL IMPACT THROUGH MODELLING.

THE TWELVE TESTS IN THE ASSESSMENT PROTOCOL MAY BE CLASSIFIED EITHER AS PHYSICAL OR CHEMICAL TESTS. THE SEVEN PHYSICAL TESTS WILL BE DISCUSSED FIRST. BULK DENSITY, WATER CONTENT AND SPECIFIC GRAVITY ARE ENGINEERING PROPERTIES WHICH HAVE NO DIRECT ENVIRONMENTAL SIGNIFICANCE, BUT ARE NECESSARY FOR CALCULATING POROSITY, AND MAY POTENTIALLY BE CORRELATED WITH OTHER PROPERTIES OF GREATER ENVIRONMENTAL INTEREST, SUCH AS DIFFUSIVITY, PERMEABILITY, AND RESISTANCE TO WEATHERING.

SLIDE 2 SHOWS THE RANGES OF THESE PROPERTIES WHICH WERE OBSERVED FOR ALL 69 SOLIDIFIED PRODUCTS TESTED. BULK DENSITIES RANGED FROM LIGHTER THAN WATER (0.7 G/CM^3), TO VERY DENSE (2.2 G/CM^3). WATER CONTENT RANGED FROM NEGLIGIBLE TO 64%. SPECIFIC GRAVITIES WERE MEASURED AROUND 2.5, WHICH IS IN THE SAME RANGE AS A TYPICAL SOIL. REPRODUCIBILITY OF A TEST WAS DETERMINED BY PLOTTING THE VALUE OF A PARAMETER MEASURED IN ONE LAB (X) VS THE VALUE MEASURED IN THE OTHER LAB (Y). IF A LINE WITH EQUATION X=Y RESULTED, REPRODUCIBILITY WAS JUDGED TO BE GOOD. REPRODUCIBLITY WAS GOOD FOR BULK DENSITY AND WATER CONTENT MEASUREMENTS, BUT VERY POOR FOR SPECIFIC GRAVITY MEASUREMENT. THE SPECIFIC GRAVITY MEASUREMENT TECHNIQUE THAT WE USED WAS A WET METHOD, USING WATER TO FILL THE POROSITY OF THE MATRIX. IT IS SUSPECTED THAT POOR REPRODUCIBILITY WAS OBSERVED BECAUSE OF VARIABLE MATRIX SOLUBILITY, OR POOR SAMPLE SATURATION, OR BOTH. A DRY METHOD, USING ARGON OR NITROGEN TO FILL THE PORE SPACES IS UNDER INVESTIGATION.

THE UNCONFINED COMPRESSIVE STRENGTH IS A MEASURE OF A SAMPLE'S ABILITY TO RESIST MECHANICAL STRESSES. AS MENTIONED EARLIER, THE MONOLITHIC NATURE OF MOST SOLIDIFIED WASTE IS A KEY FACTOR IN THE PREVENTION OF LEACHING. UCS'S RANGING FROM 11 TO 3000 PSI WERE OBSERVED. IT IS NOT EXPECTED THAT A WASTE FORM IN A LANDFILL WOULD UNDERGO MECHANICAL STRESSES GREATER THAN 50 PSI, AS A RESULT OF OVERBURDEN AND EARTH MOVING EQUIPMENT. THUS MOST SAMPLES HAVE

PHYSICAL PROPERTIES

TEST	RANGE	REPRODUCIBILITY
BULK DENSITY	0.7 to 2.2 g/cm^3	GOOD
UNCONFINED COMPRESSIVE STRENGTH	11 to 3000 psi	GOOD
WATER CONTENT	0.9 to 64 %	GOOD
SPECIFIC GRAVITY	~ 2.5	VERY POOR
HYDRAULIC CONDUCTIVITY	10^{-6} to 10^{-10} m/s	N/A

SLIDE 2

MORE THAN SUFFICIENT UNCONFINED COMPRESSIVE STRENGTH.

THE HYDRAULIC CONDUCTIVITY OF A SOLIDIFIED WASTE, AND THAT OF ITS SURROUNDINGS IN A DISPOSAL SITE, DETERMINES WHETHER GROUNDWATER FLOW WILL OCCUR THROUGH THE WASTE BODY, SUCH THAT RAPID WASHOUT OF THE SOLUBLE CONTAMINANTS OCCURS, OR AROUND THE WASTE BODY, SUCH THAT SLOW DIFFUSION OF THE CONTAMINANTS THROUGH THE WASTE MASS MUST OCCUR BEFORE THEY ENTER THE GROUNDWATER. THE RANGE OF HYDRAULIC CONDUCTIVITIES MEASURED IS FROM 10^{-6} TO 10^{-10} M/S. FOR COMPARISON PURPOSES, SAND HAS A HYDRAULIC CONDUCTIVITY IN THE RANGE OF 10^{-6}, WHILE THAT FOR CLAY IS USUALLY LESS THAN 10^{-8}. A FALLING-HEAD METHOD IN A TRIAXIAL CELL WAS USED, WHICH SHOWED REASONABLE REPRODUCIBILITY.

FREEZE/THAW AND WET/DRY WEATHERING TESTS WERE PERFORMED TO PROVIDE MEASURES OF A SAMPLE'S RESISTANCE TO SEASONAL WEATHER CONDITIONS. TO CARRY OUT THE FREEZE/THAW TEST, A MONOLITHIC SAMPLE WAS SUBJECTED TO 12 ALTERNATE CYCLES OF FREEZING AT -20^{0}C FOR 24 HOURS FOLLOWED BY THAWING IN WATER FOR 24 HOURS. WEIGHT LOSS WAS MEASURED AFTER EACH CYCLE AND COMPARED TO THAT OF A CONTROL SAMPLE. THE WET/DRY TEST WAS SIMILAR, EXCEPT THAT THE SAMPLE WAS DRIED IN AN OVEN WITH DRY AIR FOR 24 HOURS, RATHER THAN FROZEN. AGAIN, A WIDE RANGE OF RESULTS WAS OBSERVED, RANGING FROM COMPLETE DISINTEGRATION OF THE SAMPLE AFTER ONLY ONE CYCLE, TO NEGLIGIBLE WEIGHT LOSS AFTER 12 CYCLES. IT WAS FOUND THAT MOST SAMPLES WHICH RESISTED 12 FREEZE/THAW CYCLES, ALSO RESISTED 12 WET/DRY CYCLES, ALTHOUGH THE REVERSE WAS NOT NECESSARILY TRUE; SINCE THE FREEZE/THAW TEST WAS SHOWN TO BE THE MORE RIGOROUS OF THE TWO. IT ALSO APPEARS THAT SAMPLES WITH A HIGH COMPRESSIVE STRENGTH TENDED TO FARE BETTER IN THE WEATHERING TESTS, BUT THIS APPARENT CORRELATION NEEDS TO BE MORE THOROUGHLY INVESTIGATED. REPRODUCIBILITY OF THE FREEZE/THAW TEST WAS GOOD. THE WET/DRY TEST WAS NOT AS REPRODUCIBLE, PROBABLY BECAUSE IT WAS

DIFFICULT TO MAINTAIN STANDARD CONDITIONS IN THE DRYING OVEN.

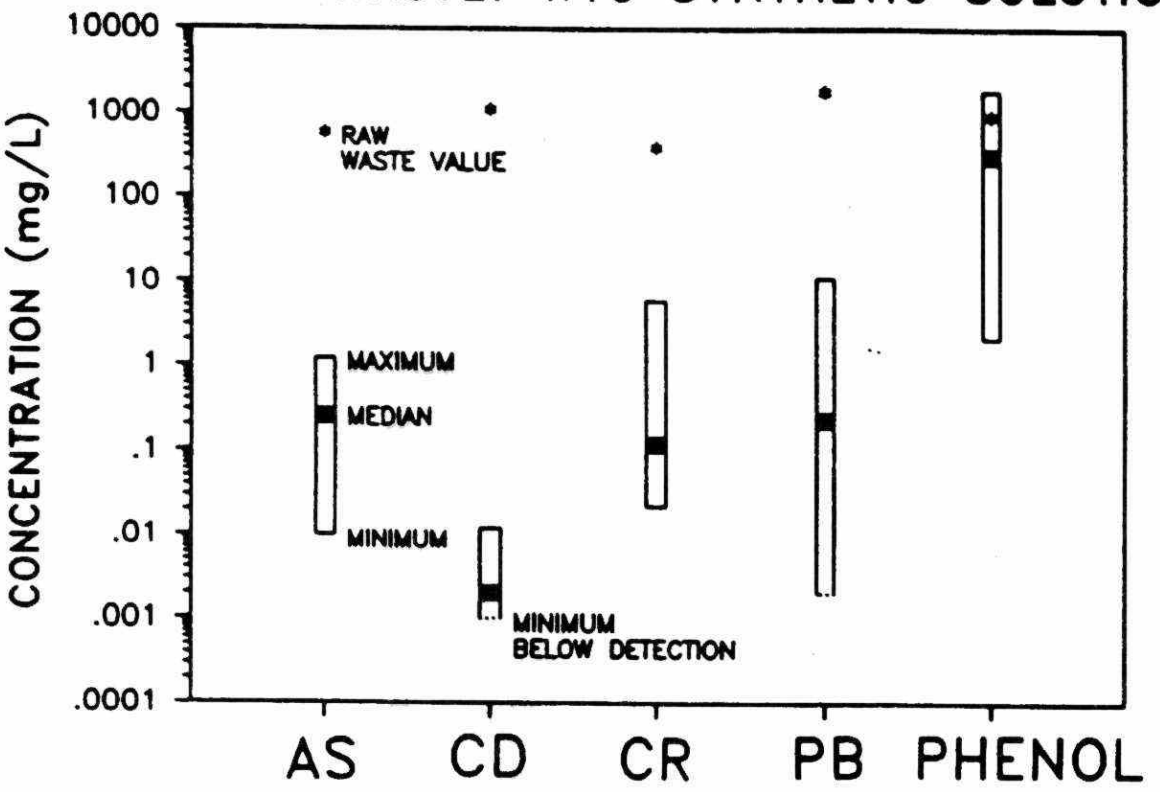
FIVE LEACHING TESTS WERE ALSO INVESTIGATED. THE EQUILIBRIUM LEACH TEST IS ACTUALLY A BATCH EXTRACTION RATHER THAN A TRUE LEACHING TEST. IT IS DESIGNED TO DETERMINE WHICH CONTAMINANTS HAVE BEEN INSOLUBILIZED BY SOLIDIFICATION. THE CONCENTRATIONS IN THE EXTRACT FROM THIS TEST MAY ALSO PROVIDE ESTIMATES OF THE PORE WATER COMPOSITION OF THE SOLIDFIED WASTE. A SAMPLE OF GROUND WASTE IS CONTINUOUSLY MIXED WITH DISTILLED WATER FOR SEVEN DAYS AT A LOW LIQUID TO SOLID RATIO (4:1). THE FILTERED EXTRACT IS ANALYSED FOR THE CONTAMINANTS OF INTEREST. DEPENDING ON THE CONTAMINANT AND THE RAW WASTE, CONCENTRATIONS IN THE EXTRACTS FROM THE DIFFERENT SOLIDIFIED PRODUCTS SPANNED 1 TO 5 ORDERS OF MAGNITUDE. GENERALLY METALS WERE OBSERVED AT LOW CONCENTRATIONS, LESS THAN 1 MG/L, WHILE ORGANICS WERE FOUND AT LEVELS UP TO 1000 TIMES HIGHER.

SLIDE 3 SHOWS CONCENTRATION RANGES OBSERVED FOR SOLIDIFIED PRODUCTS OF THE WTC SYNTHETIC SOLUTION. THE Y-AXIS IS A LOGARITHMIC CONCENTRATION SCALE. THE TOP OF THE BAR FOR EACH CONTAMINANT REPRESENTS THE MAXIMUM CONCENTRATION OBSERVED, THE BOTTOM REPRESENTS THE MINIMUM, AND THE DARK SQUARE REPRESENTS THE MEDIAN. WE CAN OBSERVE A RANGE SPANNING 2 ORDERS OF MAGNITUDE FOR ARSENIC, AND 4 ORDERS OF MAGNITUDE FOR LEAD. WE ALSO SEE THAT WHILE THE CONCENTRATION OF PHENOL IN THE EXTRACT FROM AT LEAST 1 SOLIDIFIED PRODUCT WAS AS LOW AS 1 MG/L, THE MAJORITY OF SOLIDIFIED PRODUCTS PRODUCED AN EXTRACT WITH GREATER THAN 100 MG/L PHENOL. THE ASTERISKS REPRESENT CONCENTRATIONS IN THE EXTRACT FROM THE RAW WASTE. SOLIDIFICATION SIGNIFICANTLY DECREASED THE AVAILABILITY OF THE METALS, BUT NOT NECESSARILY THE PHENOL.

SLIDE 4 SHOWS THE SAME KIND OF GRAPH FOR SOLIDIFIED PRODUCTS FROM THE DREDGE

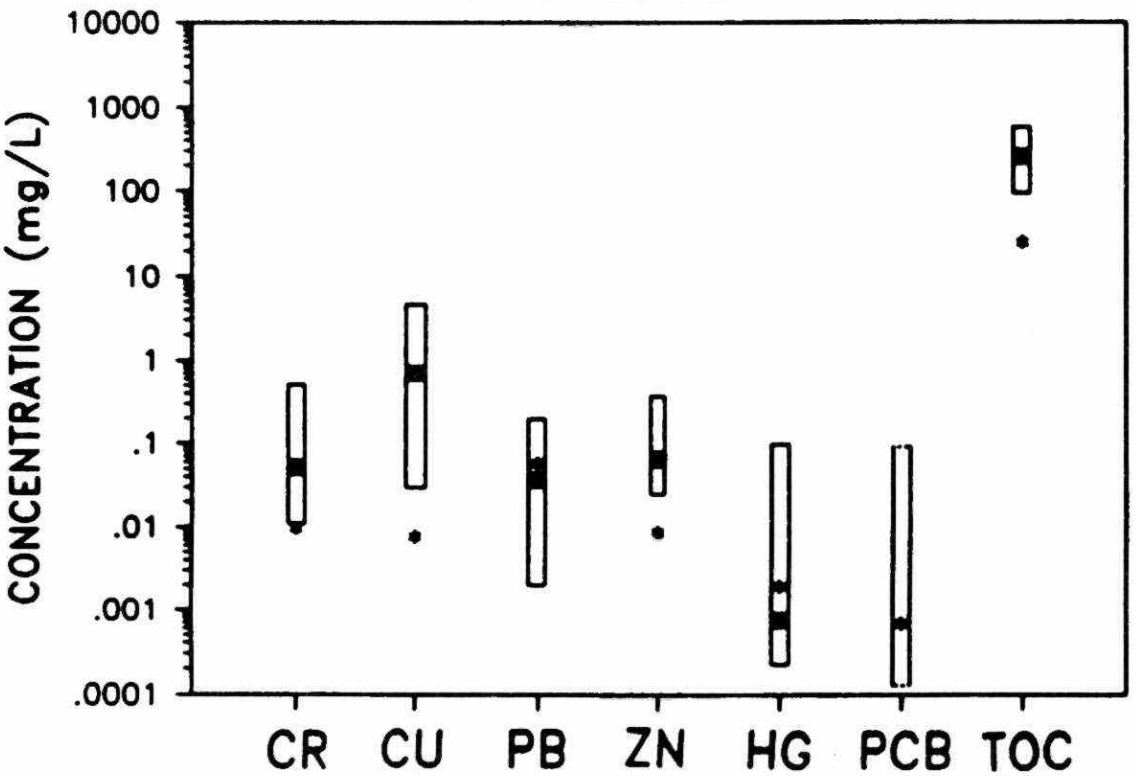
EQUILIBRIUM LEACH TEST RESULT RANGES FOR 15 PRODUCTS

RAW WASTE: WTC SYNTHETIC SOLUTION



SLIDE 3

RAW WASTE: DREDGE SPOILS



SLIDE 4

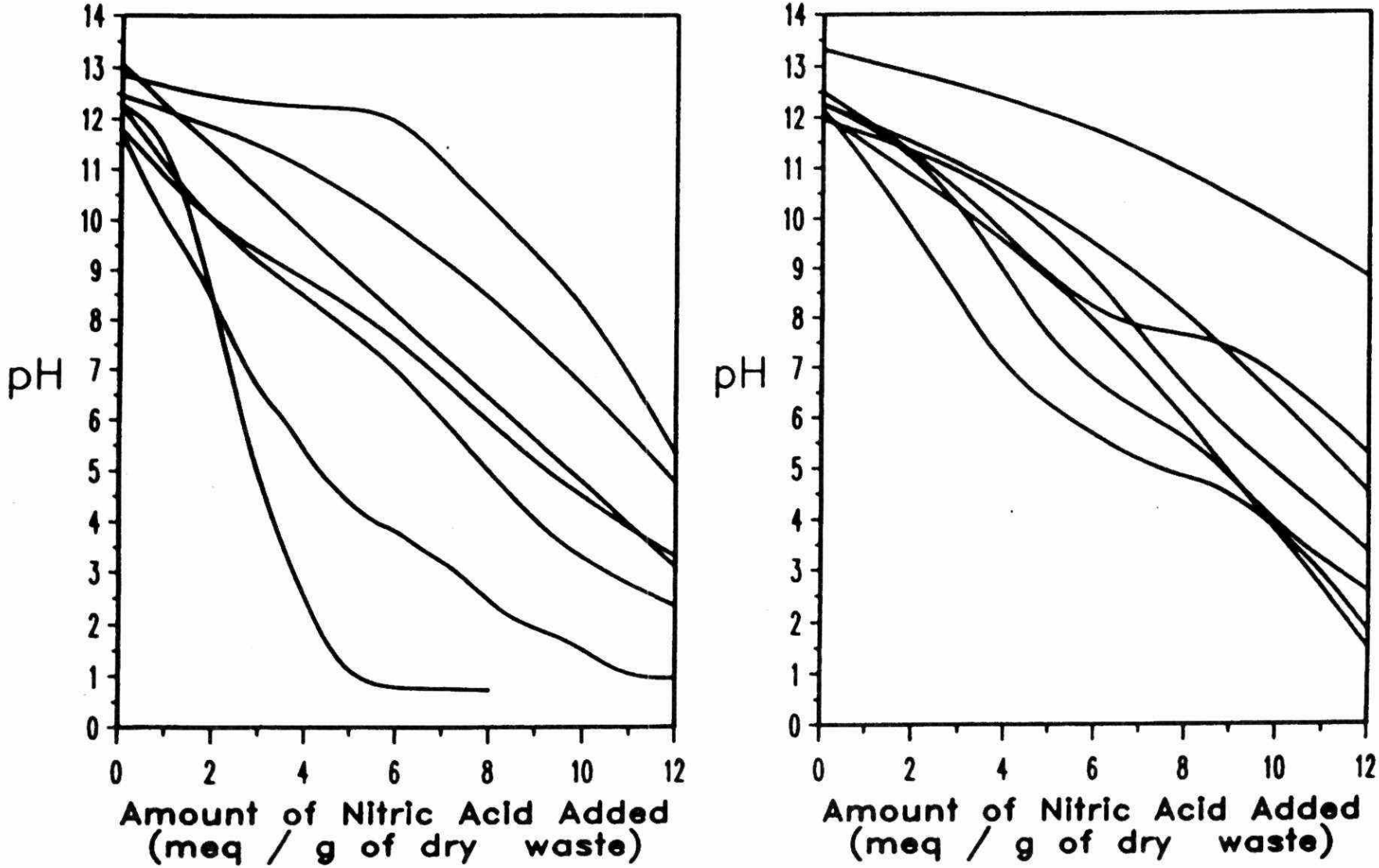
SPOILS. HERE IT CAN BE SEEN THAT SOLIDIFICATION HAS NOT DECREASED THE SOLUBILITY OF THE CONTAMINANTS, IN FACT IT APPEARS THAT SOLUBILITY OF CHROMIUM, COPPER, AND ZINC HAS BEEN SIGNIFICANTLY INCREASED. THIS REMARKABLE FACT CAN BE ATTRIBUTED TO 2 CAUSES: 1) SINCE A DREDGE SPOIL IS ANAEROBIC, INSOLUBLE CHELATES MAY BE PRESENT UNDER REDUCING CONDITIONS, BUT WHEN THE WASTE IS EXPOSED TO AIR, AS IT WOULD BE DURING MIXING OF A SOLIDIFIED WASTE, THESE SPECIES ARE OXIDIZED, ALSO, 2) THE pH OF A SOLIDIFIED WASTE IS OFTEN 12 OR GREATER. SINCE MANY METALS ARE AMPHOTERIC, THEY MAY FORM INSOLUBLE COMPOUNDS AT NEUTRAL pH, WHICH WOULD BE THE USUAL pH OF A DREDGE SPOIL, BUT COME INTO SOLUTION AT pHs GREATER THAN 10 OR 11.

THE US EPA TOXICITY CHARACTERISTIC LEACHING PROCEDURE IS ALSO A BATCH EXTRACTION, BUT AT A LOW pH, SO THAT SOLUBILITY OF THE CONTAMINANTS UNDER MORE AGGRESSIVE CONDITIONS IS MEASURED. A CRUSHED SAMPLE IS EXTRACTED FOR 18 HOURS AT A HIGH LIQUID TO SOLID RATIO (20:1) WITH A pH 2.88 ACETIC ACID EXTRACTION LIQUID. CONCENTRATIONS OBSERVED IN THE EXTRACT WERE SIMILAR TO THOSE OBSERVED IN THE EQUILIBRIUM LEACH TEST EXTRACT, BUT THE ACIDITY RESULTED IN SLIGHTLY HIGHER METALS CONCENTRATIONS.

THE ABILITY OF A SOLIDIFIED PRODUCT TO NEUTRALIZE ACID ADDITIONS WAS MEASURED USING A NUMBER OF BATCH EXTRACTIONS. A SAMPLE OF GROUND WASTE WAS DIVIDED INTO ELEVEN SUBSAMPLES, WHICH WERE PLACED IN TEST TUBES, AND AN INCREASING AMOUNT OF NITRIC ACID WAS ADDED TO EACH SUCCESSIVE TEST TUBE. THE TEST TUBES WERE MIXED UNTIL EQUILIBRIUM WAS REACHED, AND THEN THE pH WAS MEASURED IN EACH TUBE.

THE RESULTS CAN BE EXPRESSED AS TITRATION CURVES. THE GRAPHS IN SLIDE 5 SHOW THE pH IN THE SUBSAMPLES AS A FUNCTION OF THE AMOUNT OF ACID ADDED FOR DIFFERENT SOLIDIFIED SAMPLES OF THE SYNTHETIC HEAVY METAL HYDROXIDE SLUDGE.

ACID NEUTRALIZATION CAPACITY FOR EACH SOLIDIFICATION PRODUCT WES SYNTHETIC SLUDGE



SLIDE 5

EACH LINE REPRESENTS THE "TITRATION CURVE" FOR A DIFFERENT SOLIDIFIED PRODUCT. THE GRAPHS HAVE BEEN DIVIDED INTO TWO GROUPS FOR EASY VIEWING. WE CAN SEE THAT THE AMOUNT OF ACID NECESSARY TO BRING THE pH DOWN TO APPROXIMATELY 9 (WHERE MANY METAL HYDROXIDES BEGIN TO COME INTO SOLUTION) VARIES FROM 2 MEQ/G OF DRY WASTE TO 12 MEQ/G OF DRY WASTE. DEPENDING ON THE pH OF THE GROUNDWATER, AND THE WASTE, THE EQUIVALENT AMOUNT OF GROUNDWATER FOR THE ACID NEUTRALIZATION CAPACITY TO BE NEUTRALIZED MAY BE CALCULATED. FOR INSTANCE, 1 KG OF A SOLIDIFIED WASTE WITH AN ACID NEUTRALIZATION CAPACITY OF 2 MEQ/G CAN NEUTRALIZE 2000 L OF pH 3 GROUNDWATER. THE ACID NEUTRALIZATION CAPACITY OF A SOLIDIFIED WASTE IS IMPORTANT BECAUSE METALS TEND TO BECOME MORE SOLUBLE UNDER ACIDIC CONDITIONS. A LOW pH ALSO DESTROYS A CEMENT MATRIX.

A SEQUENTIAL CHEMICAL EXTRACTION WAS USED TO ATTEMPT TO DETERMINE THE SPECIATION OF HEAVY METAL CONTAMINANTS IN A SOLIDIFIED PRODUCT. KNOWLEDGE OF THE BONDING CHARACTERISTICS OF THE METALS LEADS TO AN IMPROVED UNDERSTANDING OF THE ENVIRONMENTAL LEACHANTS THAT COULD AFFECT THEIR SOLUBILITY. A SAMPLE OF GROUND WASTE IS TREATED BY 5 SUCCESSIVE CHEMICAL EXTRACTIONS OF INCREASING AGGRESSIVENESS, RANGING FROM ION-EXCHANGE WITH LITHIUM CHLORIDE TO TOTAL DIGESTION WITH HYDROFLUORIC ACID, TO SEPARATE THE CONTAMINANTS INTO FIVE FRACTIONS. THE COMPOUNDS IN EACH SUCCESSIVE FRACTION ARE MORE REFRACTORY THAN IN THE PREVIOUS ONE. THIS TEST WAS ADAPTED FOR USE WITH SOLIDIFIED WASTES FROM AN EXTRACTION FOR TRACE METALS IN SEDIMENTS. ALTHOUGH ORIGINALLY EACH FRACTION WAS DESIGNED TO EXTRACT SPECIFIC COMPOUNDS, THE ASSUMPTIONS USED IN EXTRACTING SOLIDIFIED WASTES MAY NEED TO BE DIFFERENT THAN FOR SEDIMENTS. UNTIL THIS MATTER IS RESOLVED, THE RESULTS FROM THIS TEST CAN BE REPORTED AS 2 FRACTIONS ONLY; FRACTIONS A,B, AND C TOGETHER ARE CLASSIFIED AS "AVAILABLE FOR SHORT AND MEDIUM- TERM LEACHING",

AND FRACTIONS D AND E ARE "UNAVAILABLE FOR LEACHING". THE MAJORITY OF CONTAMINANTS WERE "AVAILABLE FOR LEACHING" IN MOST SAMPLES, ALTHOUGH SOME PRODUCTS DID MANAGE TO SPECIATE ALMOST 100% OF SOME CONTAMINANTS AS "UNAVAILABLE FOR LEACHING". AS A RESULT OF THIS STUDY, IT HAS BECOME CLEAR THAT THIS TEST NEEDS TO BE FURTHER DEVELOPED, AND THAT IT IS NOT APPLICABLE TO DETERMINING SPECIATION OF ARSENIC OR MERCURY.

THE LAST LEACHING TEST THAT WAS APPLIED TO THE STUDY SAMPLES WAS THE DYNAMIC LEACH TEST, WHICH WAS ADAPTED FROM THE AMERICAN NUCLEAR SOCIETY TEST 16.1. THIS TEST IS A TRUE LEACHING TEST, WHICH IS USED TO DETERMINE THE MOBILITY OF THE CONTAMINANTS THROUGH THE SOLIDIFIED WASTE MATRIX. A MONOLITHIC SPECIMEN WAS IMMERSED IN DISTILLED WATER AT A SPECIFIC VOLUME TO SURFACE AREA RATIO. THE LEACHANT WAS RENEWED AT INTERVALS CALCULATED ACCORDING TO A DIFFUSION MODEL, OVER A PERIOD OF NINE DAYS. FROM THE AMOUNT LEACHED IN EACH INTERVAL, RELATIVE TO THE TOTAL AMOUNT OF CONTAMINANT INITIALLY PRESENT, AN APPARENT DIFFUSION COEFFICIENT WAS CALCULATED FOR EACH CONTAMINANT. FOR THE DIFFERENT SOLIDIFIED PRODUCTS, THE APPARENT DIFFUSION COEFFICIENTS FOR EACH CONTAMINANT VARIED OVER 4 ORDERS OF MAGNITUDE. METALS SHOWED LOW MOBILITIES, WITH DIFFUSIVITIES RANGING FROM 10^{-10} TO 10^{-16} CM^2/S, WHILE ORGANICS SHOWED HIGH MOBILITY, WITH DIFFUSIVITIES RANGING FROM 10^{-5} TO 10^{-10} CM^2/S. THE DIFFUSION COEFFICIENT OF A COMPOUND IN PURE SOLUTION, WITHOUT MATRIX TORTUOSITY, IS IN THE ORDER OF 10^{-5} CM^2/S.

TO SUMMARIZE, THE OBJECTIVES OF THE STUDY WERE TWOFOLD: TO ASSESS THE SUITABILITY OF A PROTOCOL OF TWELVE SHORT-TERM TEST METHODS FOR CHARACTERIZING PHYSICAL AND LEACHING PROPERTIES OF SOLIDIFIED WASTES, AND TO DEVELOP A DATABASE OF SOLIDIFIED WASTE PROPERTIES.

IN DETERMINING THE SUITABILITY OF THE TEST METHODS FOR CHARACTERIZING

SOLIDIFIED WASTES, WE MUST ASSESS THE REPRODUCIBILITY OF THE TEST METHODS, AND THEIR ABILITY TO MEASURE THE PROPERTIES OF CONCERN. FOR MOST OF THE METHODS, INTER AND INTRALABORATORY REPRODUCIBILITY APPEAR TO BE WITHIN ACCEPTABLE LIMITS, ALTHOUGH MORE EXTENSIVE STATISTICAL ANALYSIS IS CURRENTLY IN PROGRESS. ANALTICAL VARIABILITY, AND SAMPLE INHOMOGENEITY WERE SIGNIFICANT FACTORS, PARTICULARLY FOR SOME CONTAMINANTS, HOWEVER, THE RANGE OF PROPERTIES WAS WIDE ENOUGH TO MAKE THEM RELATIVELY UNIMPORTANT. THE WIDE RANGES OF RESULTS MEASURED SHOW THAT THE METHODS ARE CAPABLE OF DISTINGUISHING BETWEEN DIFFERENT SOLIDIFICATION PROCESSES. THESE WIDE RANGES OF RESULTS ALSO FULFILL THE SECOND OBJECTIVE OF THE PROGRAM, WHICH WAS TO ESTABLISH A DATABASE OF INTRINSIC SOLIDIFIED WASTE PROPERITIES ACHIEVABLE WITH PRESENT TECHNOLOGY.

WE ARE STILL IN THE RELATIVELY EARLY STAGES OF INTERPRETATION OF THE DATA. THE RESULTS STILL NEED TO BE EXAMINED FOR CORRELATIONS BETWEEN DATA FROM DIFFERENT TESTS, AND MORE THOROUGH STATISTICAL ANALYSIS NEEDS TO BE CARRIED OUT. A COMPLETE REPORT WILL BE PUBLISHED TOWARDS THE END OF 1987.

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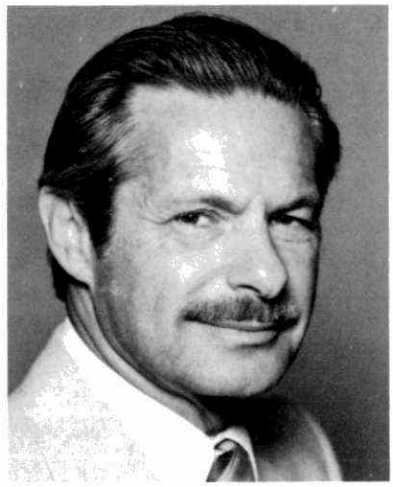

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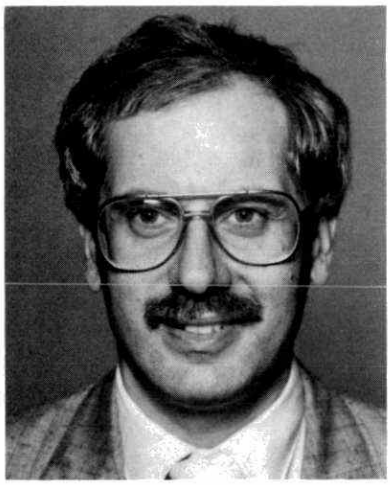

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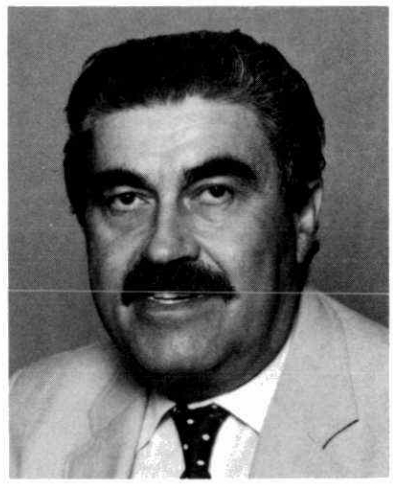

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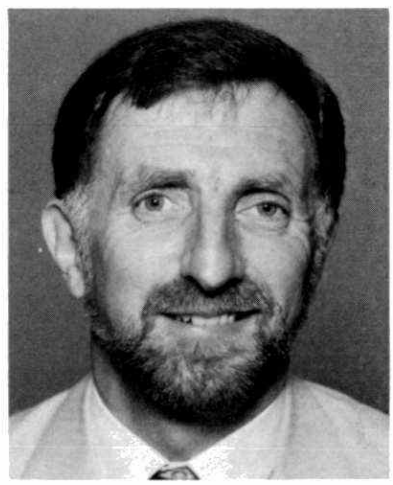

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A REVIEW OF THE ONTARIO OZONE PROBLEM

by

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In this paper, I plan to present some Ontario ozone data, look at the trends, then review albeit selectively, the past ten years of ozone work at the Air Resources Branch.

Table 1 lists the gases which have criteria in Ontario. The criteria are indicated in the final column, and the number of exceedances of these criteria is shown in the second column. Ozone is the most problematic criterion pollutant in Ontario with thirty five of forty one stations recording exceedances of the criterion in 1985. (The criterion, as indicated, is .08 ppm). For Nitrogen Dioxide, none of the stations had exceedances. For Sulfur Dioxide, 17 stations of 83 had exceedances.

All of the 40 ozone monitors in Ontario are indicated in Figure 1. Figure 2 is a close-up for Southern Ontario which has 27 monitors. The monitors are situated in both urban and rural locations; the largest urban location is the Toronto-Hamilton area.

The reference level for ozone in Ontario is the ozone criterion of 80 ppb for 1 hour. An ozone exceedance is defined as a value in excess of 80 ppb. All southwestern Ontario stations record exceedances of ozone on a regular basis (see Figure 3). The number of exceedances decreases from south to north, but there is much variability in the Toronto-Hamilton area because ozone is simultaneously being produced from precursors and scavenged by Nitric Oxide in this area. The highest number of exceedances in the province is usually at Longpoint on a peninsula extending eastward into Lake Erie. The number of exceedances between 1983 and 1985 was 504. The six stations with the most exceedances between 1983 and 1985 are shown in Figure 4.

The 1985 distribution by month is shown in Table 2, indicating most exceedances in June and July. There is considerable variability in the seasonal distribution from year to year.

We have compared the levels measured in southern Ontario with other jurisdictions, for example the Federal Republic of Germany (see Table 3).[1] Apart from Schauinsland, the number of

hours of exceedances of the 80 ppb reference level, and the maximum values, are comparable to the Southern Ontario stations.

We looked at long-term variations and Table 4 shows the annual mean (for all 8760 hours of the year) for 10 years. It shows the lack of strong trends in the southern Ontario data. It shows also that 1978 appeared to have a significantly higher average relative to the other 9 years. If we select the warm season daylight hours (Table 5), we see that 1978 stands out even further. Figure 5 depicts ozone exceedances in the ten-year period between 1976 and 1985.(Whiteface Mountain is black and Simcoe is hatched). Again 1978 stands out as a maximum for both locations, and there is general agreement between the number of exceedances observed at Simcoe, Ontario and Whiteface Mountain, New York.(1)

To better understand the ozone phenomenon, we studied widespread occurrences of high ozone which we called ozone episodes. These occurrences, typically covering hundreds of kilometres(2), are defined as one or more days of ozone greater than 80 ppb at 8 or more stations. An ozone episode-day is defined as one day of an ozone episode. An ozone episode might typically consist of several episode days.

In summarizing ten years of data for ozone episodes and ozone episode-days (Table 6), 1978 stood out with a very high number of both ozone episodes and ozone episode-days. Further study was done of ozone episodes of particularly long duration, that is three days or more. Table 7 gives the duration in days for each of these episodes. In 1976 for example, there was a three day episode in June and a three day episode in August. In 1978 there were a large number of ozone episodes and ozone episode days. This table points out that the higher than average 1983 data were heavily influenced by a single eight day episode which occurred in June.

We were able to produce an ozone climatology for the ten-year period (Table 8). We found that 63 ozone episodes consisted of a single day; 24 consisted of 2 days and so on. There was one episode which lasted 8 days.

That gave a total of 106 episodes and 185 episode days. Table 9 shows the expected number of episodes in each month; there are no expected episodes outside of the period May to September. Various studies done at the Air Resources Branch have demonstrated the meteorological conditions required for ozone episodes. These are summarized in Table 10.

Trajectory analysis indicated that source regions to the south and south-west, were impacting on southwestern Ontario during episodes. Figure 6 shows 48 hour back-trajectories, based on a surface geostrophic model with frictional corrections.([4])

Figure 7 is a classic ozone pattern, which was recorded by Wolff and Lioy in 1977.([5]) It indicates that episodes do not occur in Ontario in isolation. Normally southwestern Ontario is the extreme northerly edge of a so-called ozone river, which may sweep around an area of high pressure.([6],[7]) In this particular case, there were two high pressure centres, one just south of Lake Ontario and one over the southeastern US.

The manifestation of an ozone episode at a particular location is shown in Figure 8 for the Summer of 1984. The plots are for Simcoe, Ontario, Whiteface Mountain, and Arzberg, Germany. The diurnal patterns in Ontario and West Germany are not dissimilar. Whiteface Mountain shows a type of diurnal variation, actually not much variation at all, typical of a mountain location. There is a slight dip during the late morning hours and a maximum near midnight.

The typical diurnal variation is caused by the nocturnal inversion, which isolates the ozone above the ground.([1]) The same kind of pattern can be seen in the number of ozone exceedances for each hour of the day (Figure 9). This particular plot shows the sum of ozone exceedances during a 5 year period at three locations, and has a maximum at 5 in the afternoon and a minimum around 8 in the morning.

We have spoken so far of 80 ppb hourly exceedances, but the best documented effect of high ozone in Ontario, is related to damage to sensitive crops. The National Crop Loss Assessment Network, NCLAN, has recommended that the 7 hour seasonal mean for ozone (9 am to 4 pm) is the most relevant measure of ozone impact on crops.([8])

Thirty ppb, as a 7 hour seasonal mean, has been shown to produce little or no damage to crops. Forty ppb on the other hand, results in significant yield loses in sensitive crops. Our phyto-toxicological section has found a good correlation between a criterion of 80 ppb for 1 hour and a 7 hour seasonal mean criterion of 32 ppb. That is to say: if one criterion is met, so is the other. If one of them is not met, neither is the other.

The 7 hour seasonal mean in three different jurisdictions is shown in Figure 10. Basically what we find is that a 7 hour seasonal mean of 32 ppb, above which yield losses are expected, is regularly exceeded in southwestern Ontario as it is at Whiteface Mountain, and in Hohenpeissenberg, Germany.

The exceedances of these criteria, whether we speak of the 80 ppb (1 hour max) or the 7 hour seasonal mean of 32 ppb, result in crop yield losses valued at about 20 million dollars.([8])

Let me now briefly enter the precursor control strategy debate. Table 11 shows the 1983 estimated anthropogenic ozone precursor emissions. The total mass emissions of NOx and NMHC are almost identical. That translates roughly into a molar ratio between NMHC and NOx of 3:1. With reference to Dr. Dodge's comments([13]) on the type of control required, as a function of that ratio, Ontario should be pursuing non-methane hydrocarbon control.

At the bottom of Table 11, we indicate the NOx and NMHC emissions in 13 northeast states which impact most on Ontario.([9],[10],[11]) They are the 13 states from which most of the back trajectories

originate. For those states, the molar ratio of anthropogenic non-methane hydrocarbons to NOx is roughly 5:1. Again NMHC control would seem in order.

The natural emissions for non-methane hydrocarbons are very large in Ontario, in comparison with the anthropogenic NMHC emissions (see Table 11). If we look at the ratio between total NMHC, including both anthropogenic and natural NMHC, we find a ratio of about 60:1. For Ontario as a whole then, we might reach quite a different conclusion with respect to the type of strategy required for effective downwind ozone control.

Figure 11 depicts the EKMA curves([12]). The major source regions of Ontario lie roughly in the portion indicated by the large dot. It is clear that NMHC control (i.e. moving leftward from the dot) is much more effective than NOx control (moving downward from the dot) which will in many cases exacerbate the problem.

After one determines the type of strategy to use, different approaches would be required in different urban areas depending on the major source of each of the precursors.

These are the broad conclusions to date of the oxidant program: The Ontario ozone criterion of 80 ppb for 1 hour, which corresponds to a 7 hour seasonal mean of 32 ppb, is frequently exceeded in southwestern Ontario in the warm season, resulting in significant crop yield losses.

Ozone exceedances occur under known meteorological conditions, primarily as the result of precursors from the US, with Ontario emissions contributing only slightly to the Ontario problem but very likely contributing to the overall eastern North America problem.

Ozone is part of the long range transport of air pollutants phenomenon which includes acid rain and sulphates.

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TABLE 1

NUMBER OF ONTARIO STATIONS

RECORDING

CRITERIA EXCEEDANCES

1985

	NUMBER	TOTAL NO. STATIONS	CRITERION
SO_2	17	83	0.25
CO	1	26	30
NO_2	0	33	0.20
O_3	35	41	0.08

TABLE 2

MONTHLY DISTRIBUTION FOR STATIONS WITH OVER 50 OZONE EXCEEDANCES 1985

	LONG POINT	THEDFORD	TIVERTON	WINDSOR	SIMCOE
JAN					
FEB					
MAR					
APR	14	9	10		6
MAY	36	17	23	10	20
JUNE	18	5	9	12	13
JUL	81	25	23	36	32
AUG	24	19	9	12	-
SEPT	10	17	12	7	-
OCT					
NOV					
DEC					
TOTAL	183	92	86	77	71+

TABLE 3

COMPARISON OF RURAL OZONE EXCEEDANCES
IN ONTARIO AND WEST GERMANY
1982-1984

WEST GERMANY	No. HRS.	MAX.	ONTARIO	No.HRS.	MAX.
SCHAUINSLAND	1091	133	Long Point	452	136
BROTJACKLRIEGEL	584	122	Simcoe	426	123
WALDHOF	565	160	Huron Park	196	125
HOHENPEISSENBERG	178	133			

(FROM LEFOHN AND MOHNEN)

TABLE 4

TEN YEAR OZONE TREND (PPB)
18 SITES
ANNUAL MEAN

1976	1977	1978	1979	1980
20	20	23	20	20

1981	1982	1983	1984	1985
19	20	20	20	21

TABLE 5

TEN YEAR OZONE TREND (PPB)
18 SITES
WARM SEASON - DAYLIGHT HOURS

1976	1977	1978	1979	1980
35	34	39	32	32

1981	1982	1983	1984	1985
31	31	34	33	31

TABLE 6

HISTORY OF OZONE EPISODES
(AND EPISODE-DAYS)
IN ONTARIO

1976	1977	1978	1979	1980
11(18)	12(21)	22(43)	5(14)	8(13)

1981	1982	1983	1984	1985
12(18)	5(7)	13(25)	10(17)	8(9)

TABLE 7

SUMMARY OF OZONE EPISODES OF 3 OR MORE DAYS DURATION

	76	77	78	79	80	81	82	83	84	85
JAN										
FEB										
MAR										
APRIL										
MAY		4	7			3				
JUNE	3			4	4			8		
JUL		3,3	3,5	4,4		3			3	
AUG	3		3,4,3							
SEPT										
OCT										
NOV										
DEC										

TABLE 8

DURATION OF OZONE EPISODES
1976-1985

	FREQUENCY	
1 DAY	63	
2 DAYS	24	
3 DAYS	10	
4 DAYS	6	
5 DAYS	1	
6 DAYS	0	
7 DAYS	1	
8 DAYS	1	
	106	EPISODES
	185	EPISODES-DAYS

TABLE 9

EXPECTED NUMBER OF
OZONE EPISODES PER MONTH
FOR ONTARIO

MAY	0.9	
JUNE	2.7	
JULY	3.2	
AUGUST	1.7	
SEPTEMBER	0.8	
YEAR	9.3	EPISODES

TABLE 10

METEOROLOGICAL CONDITIONS
FOR
OZONE EPISODES

- REAR OF ANTICYCLONE
- WARM, MOIST AIR
- SOUTH OR SOUTHWEST WINDS

TABLE 11

1983 ONTARIO ANTHROPOGENIC
OZONE PRECURSOR EMISSIONS
(KT/YR)

	NOx	NMHC	
TRANSPORTATION	355	228	
POINT SOURCES	191	253	
FUEL COMBUSTION	27	96	
OTHER	23	21	
	596	598	(NATURAL = 13500)
13 NE STATES	4800	6200	(NATURAL = 9500)

FIGURE 1 ONTARIO'S 40 OZONE MONITORS

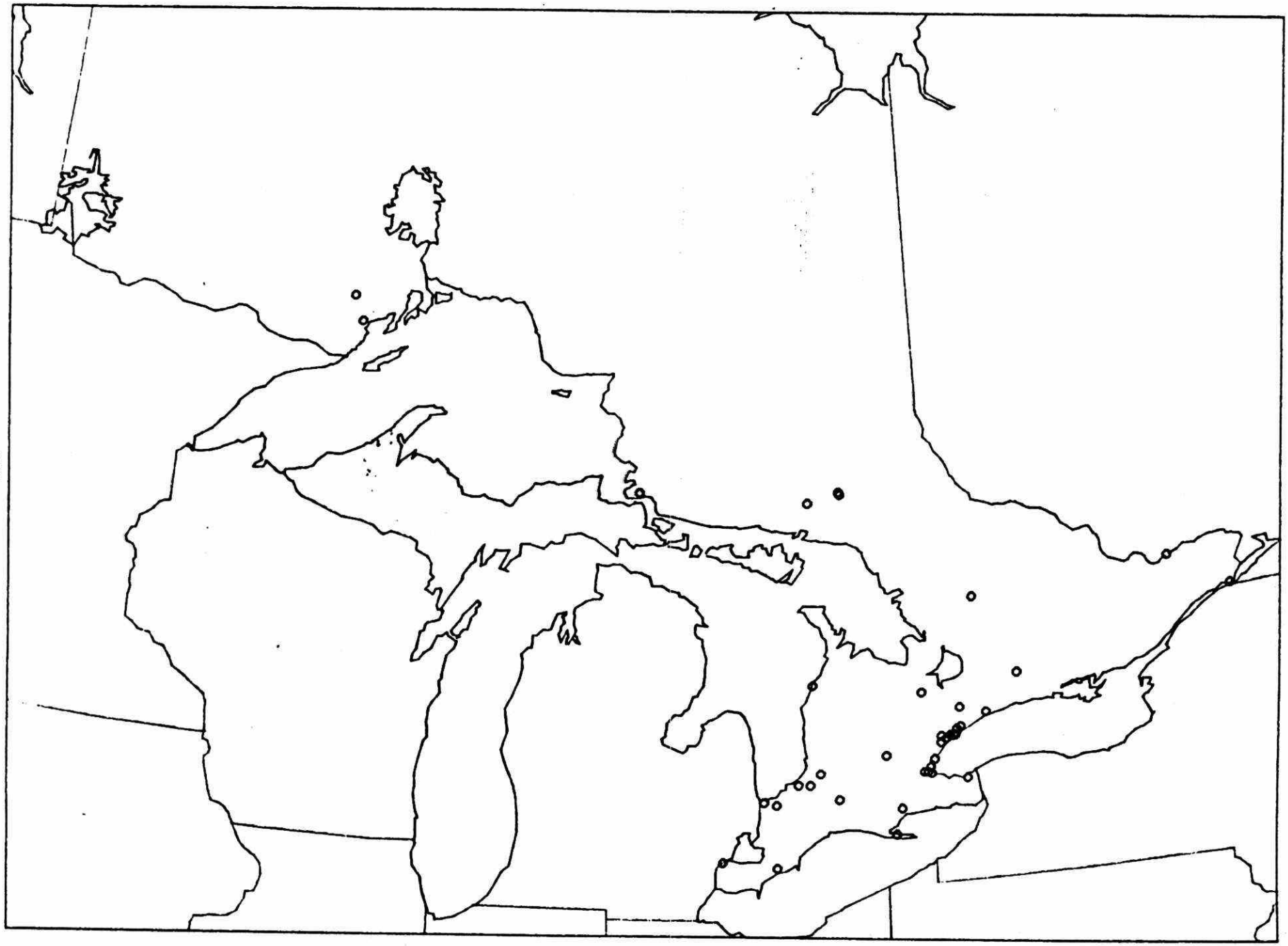


FIGURE 2 SOUTHERN ONTARIO'S 27 OZONE MONITORS

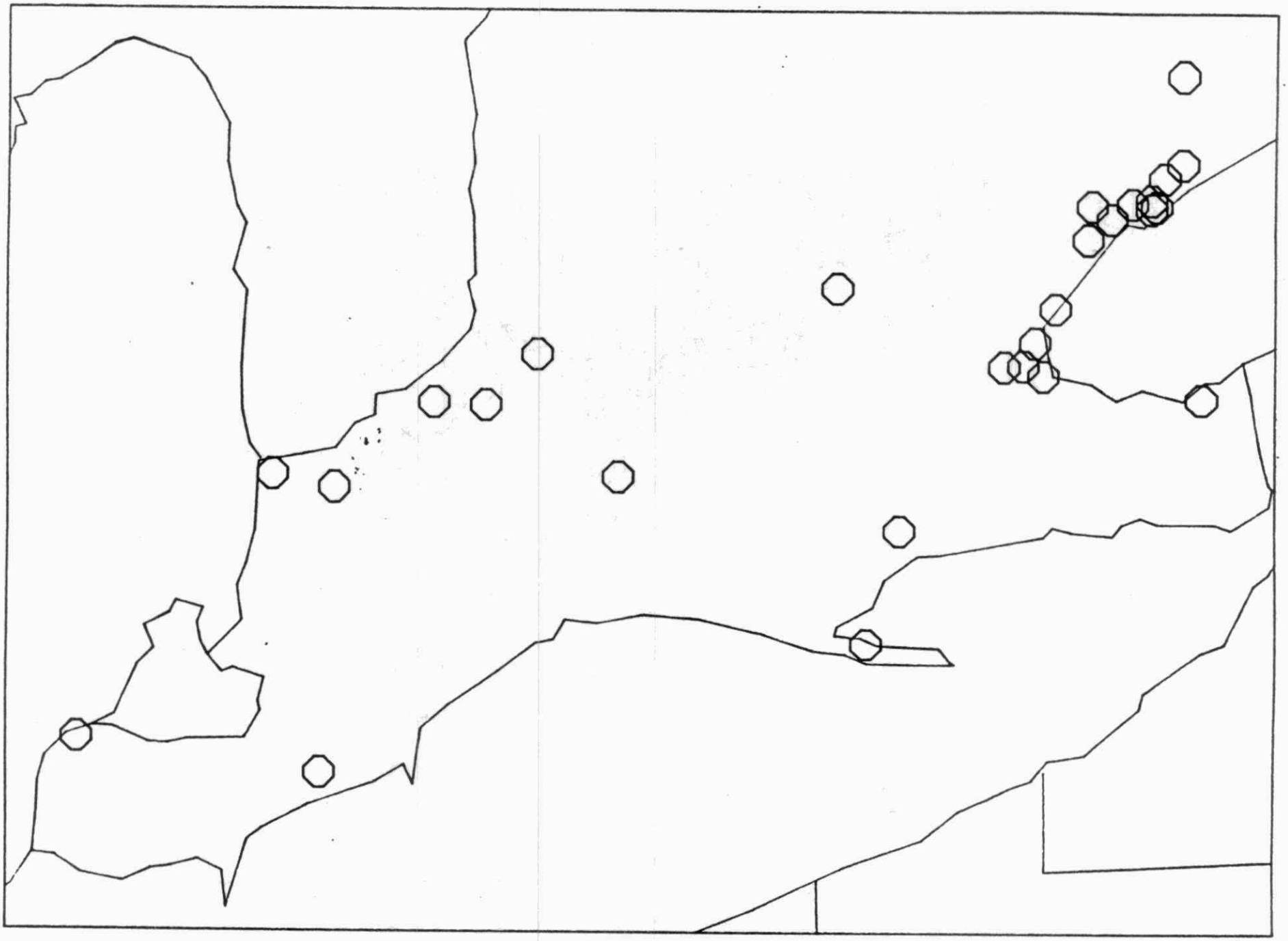


FIGURE 3 TOTAL OF OZONE EXCEEDANCES 1983 - 85

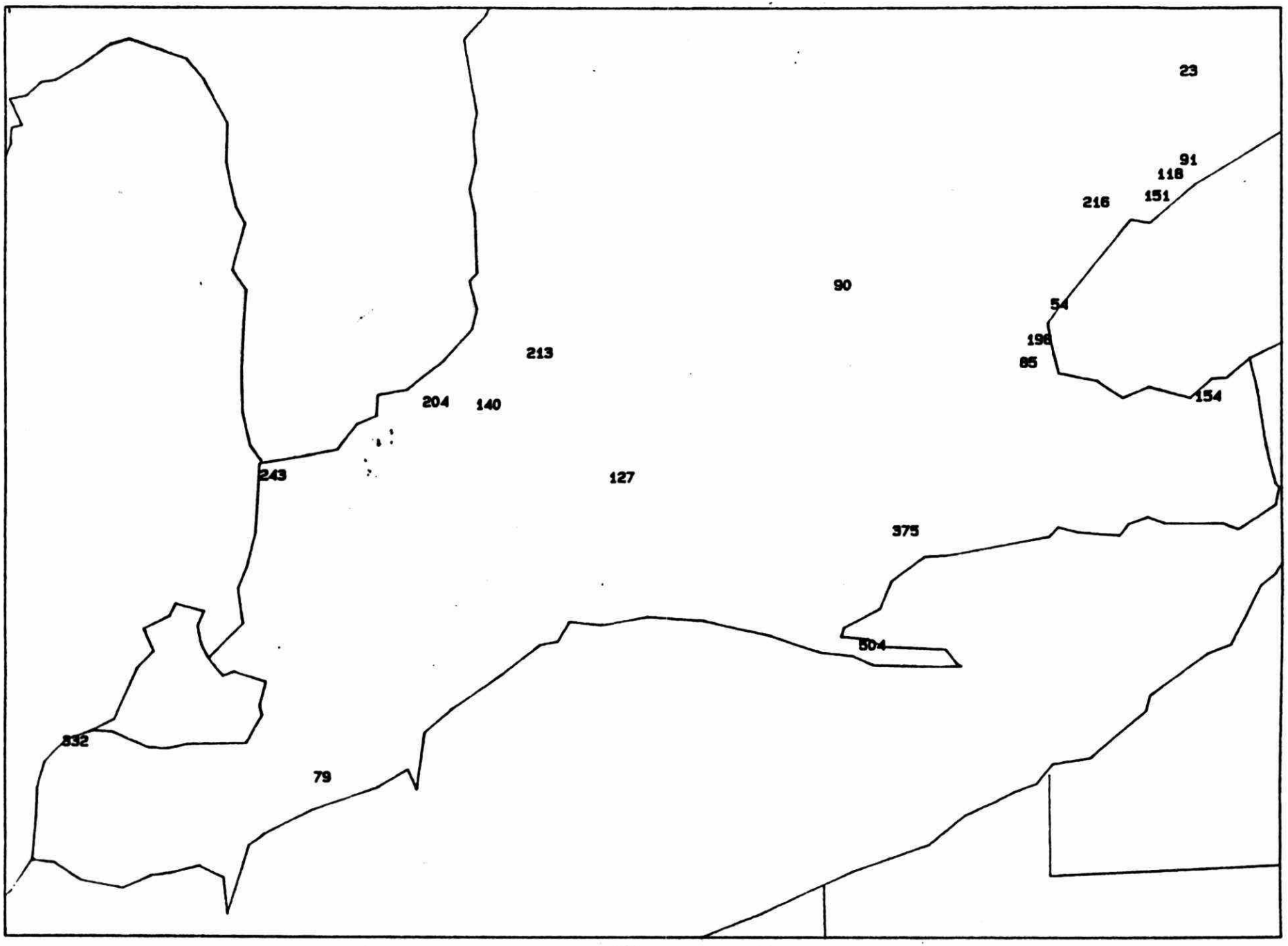


FIGURE 4 ONTARIO STATIONS MEASURING OVER 200 EXCEEDANCES 1983 - 85

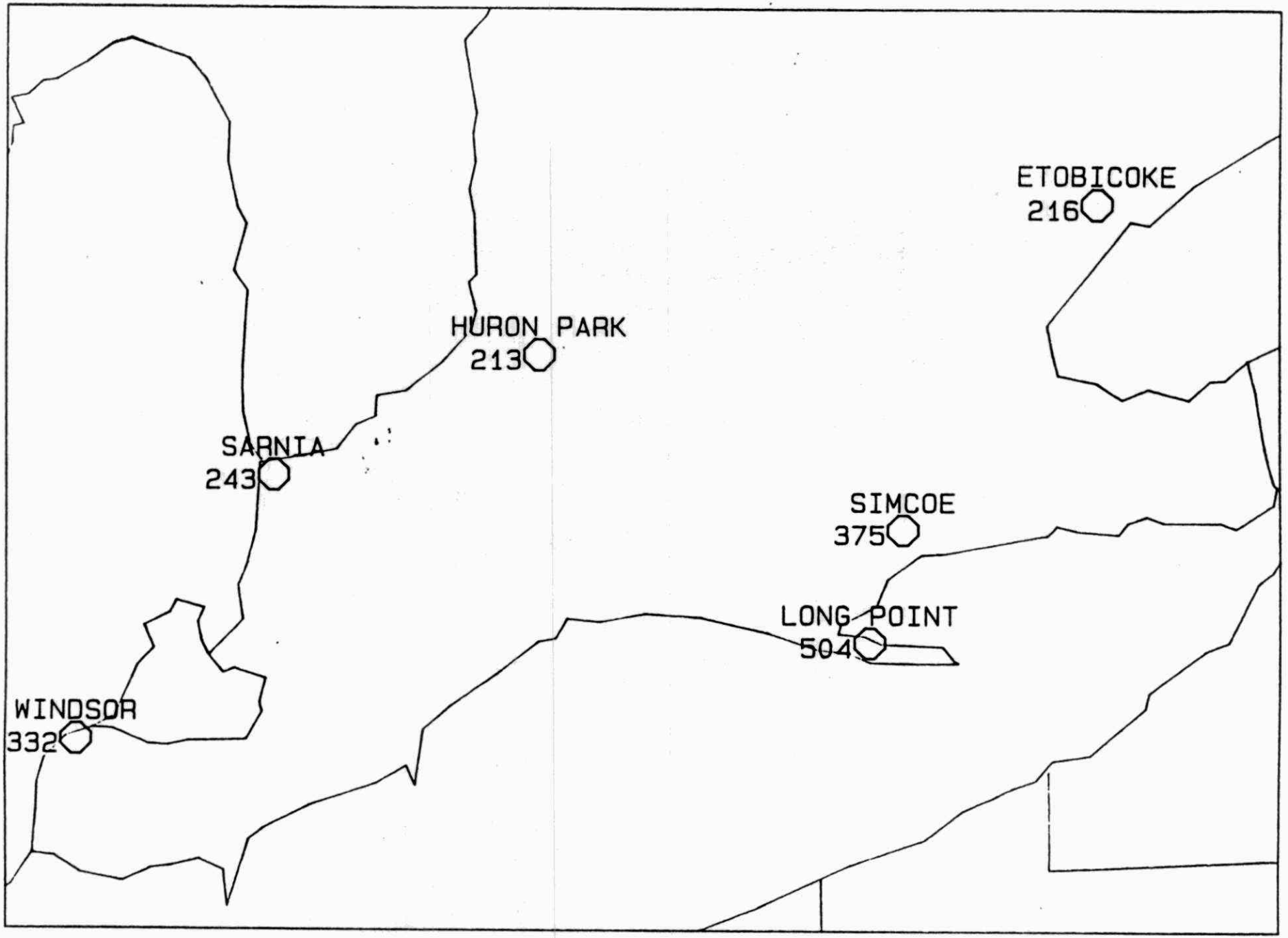


FIGURE 5

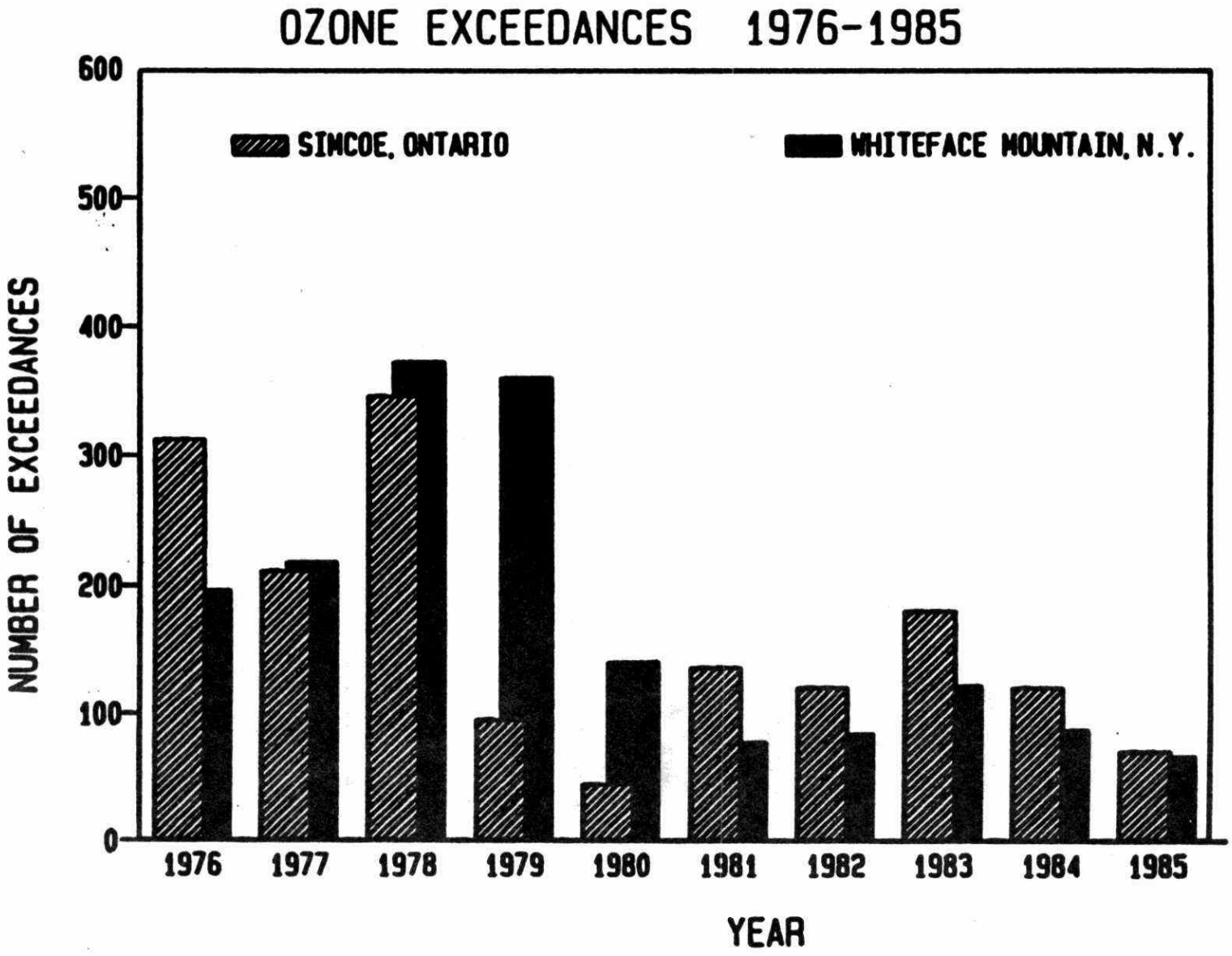

OZONE EXCEEDANCES 1976-1985
SIMCOE, ONTARIO
WHITEFACE MOUNTAIN, N.Y.
NUMBER OF EXCEEDANCES
600
500
400
300
200
100
0
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
YEAR

FIGURE 6 BACK TRAJECTORIES FROM SOUTHWESTERN ONTARIO FOR 25 OZONE EPISODE - DAYS IN 1983

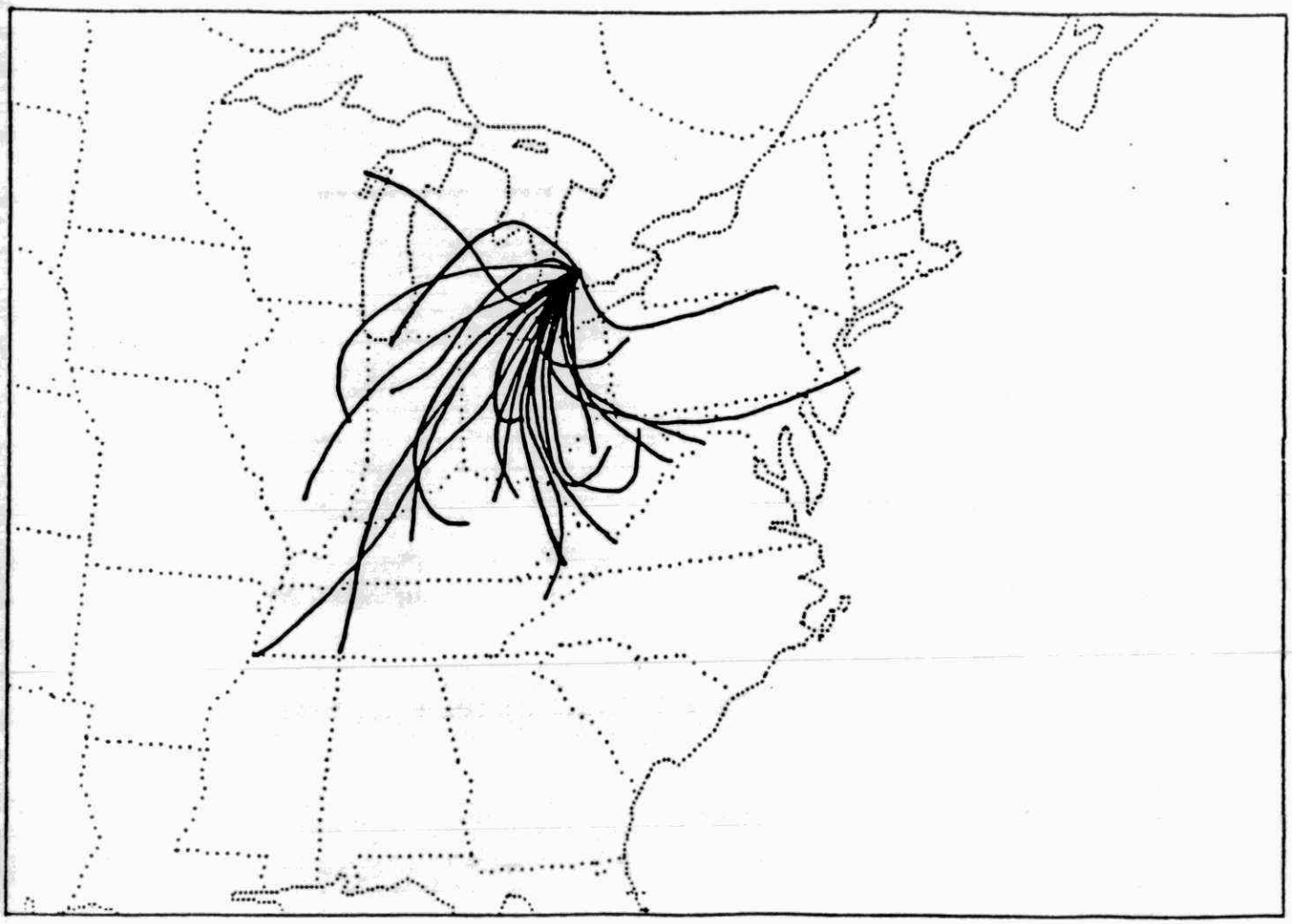


FIGURE 7 OZONE PATTERN FOR JULY 15, 1977

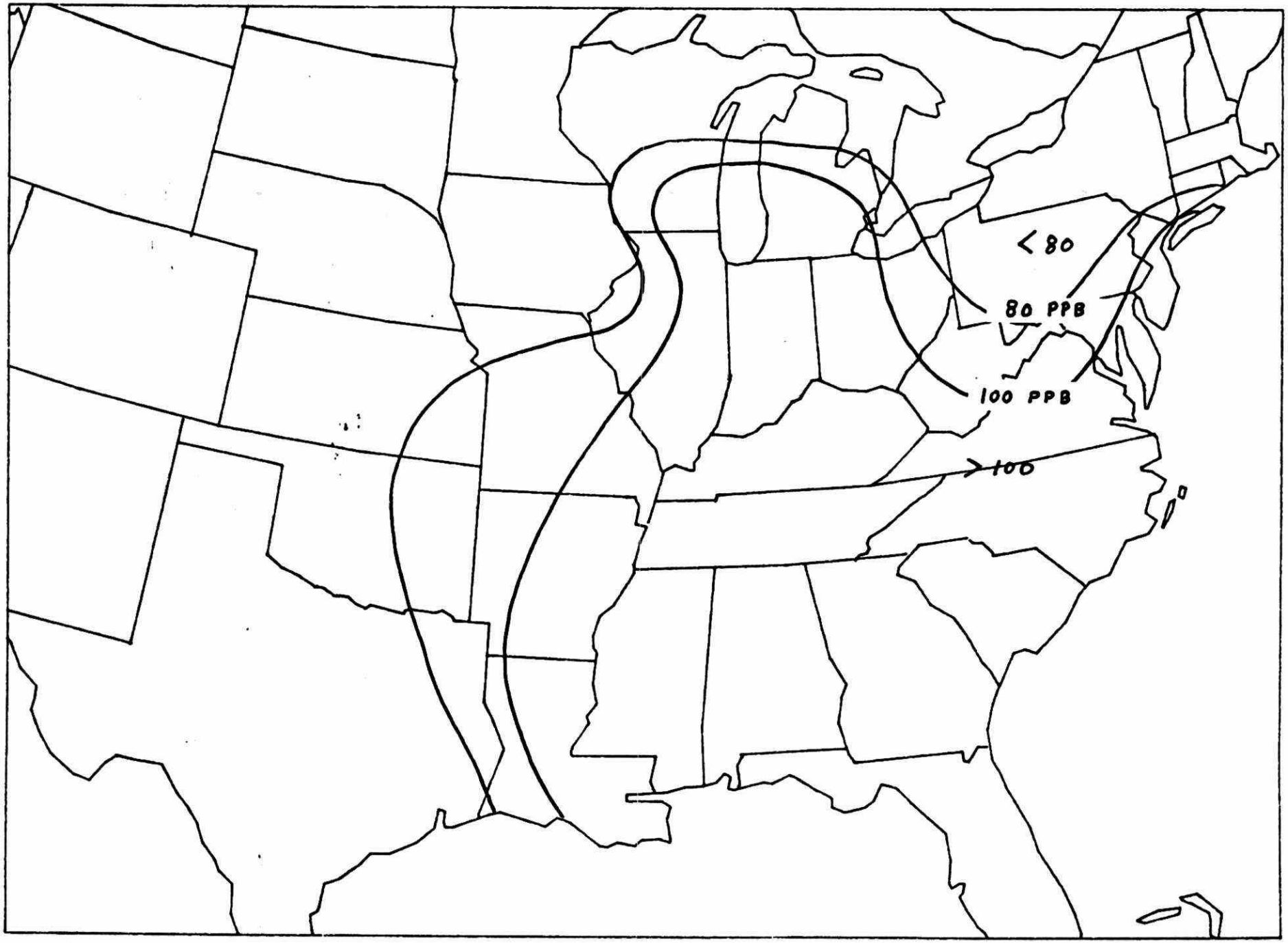


FIGURE 8

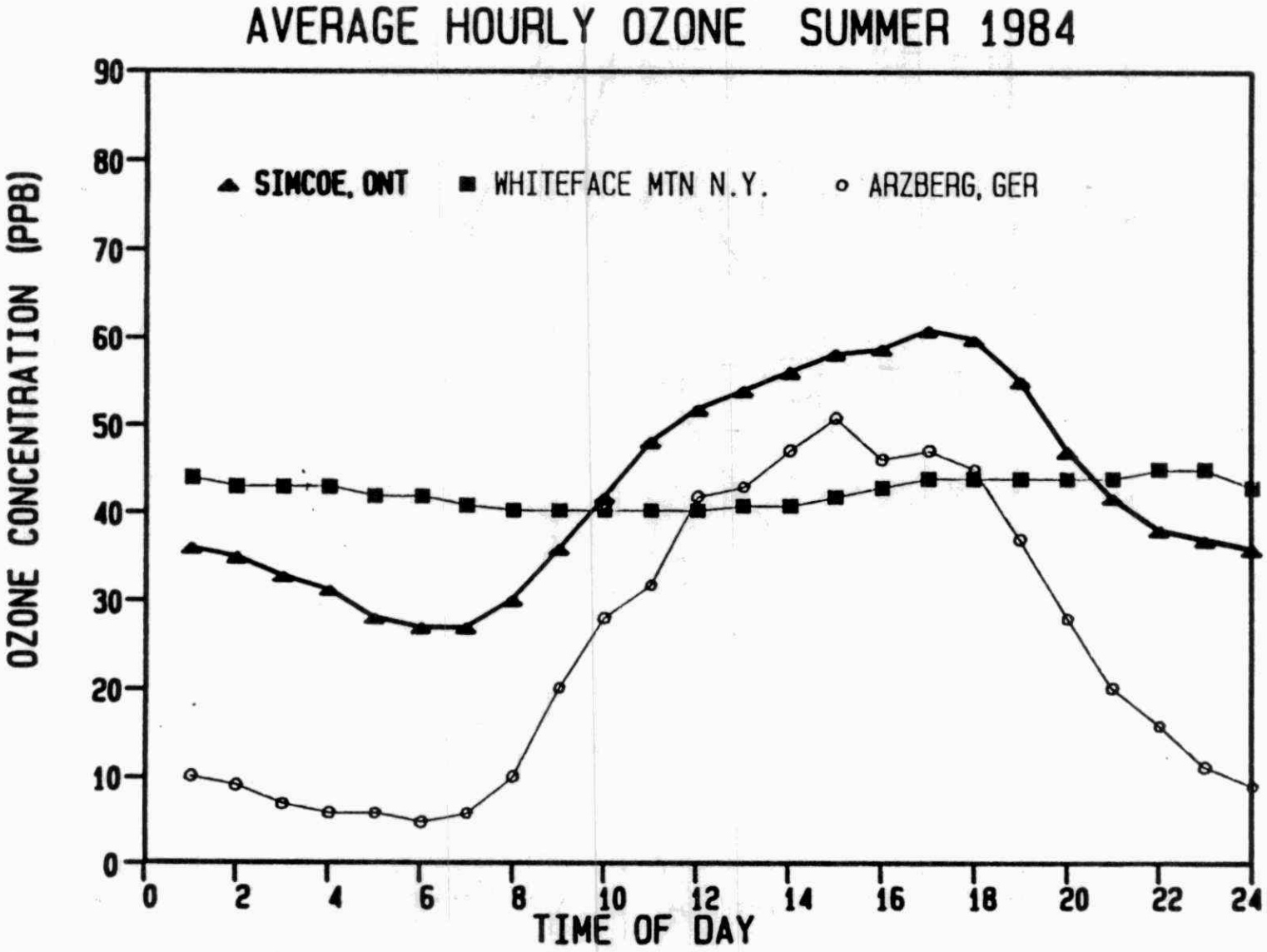

AVERAGE HOURLY OZONE SUMMER 1984
OZONE CONCENTRATION (PPB)
TIME OF DAY
SIMCOE, ONT
WHITEFACE MTN N.Y.
ARZBERG, GER
0
10
20
30
40
50
60
70
80
90
0
2
4
6
8
10
12
14
16
18
20
22
24

FIGURE 9

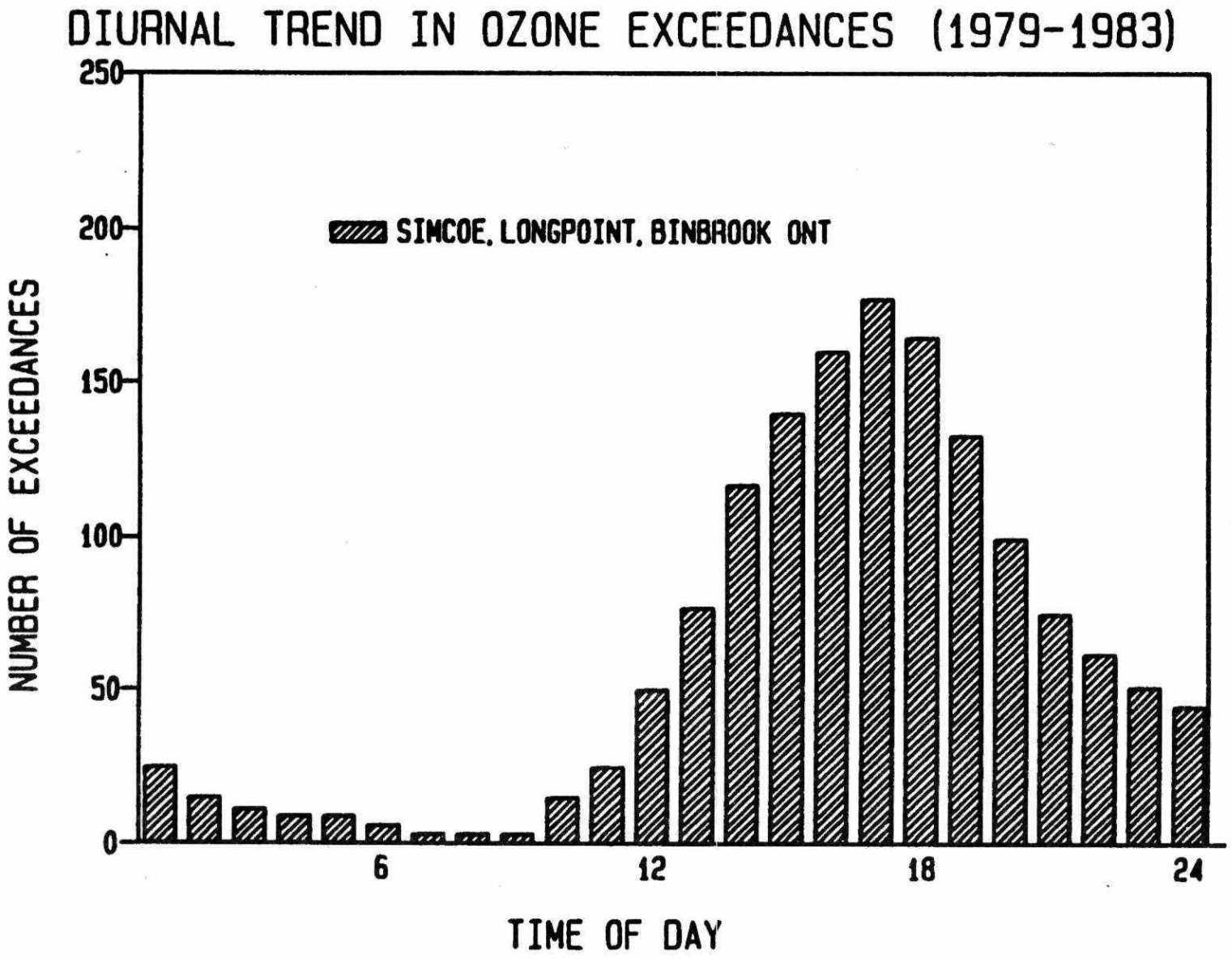

DIURNAL TREND IN OZONE EXCEEDANCES (1979-1983)
SIMCOE, LONGPOINT, BINBROOK ONT
NUMBER OF EXCEEDANCES
250
200
150
100
50
0
6
12
18
24
TIME OF DAY

FIGURE 10

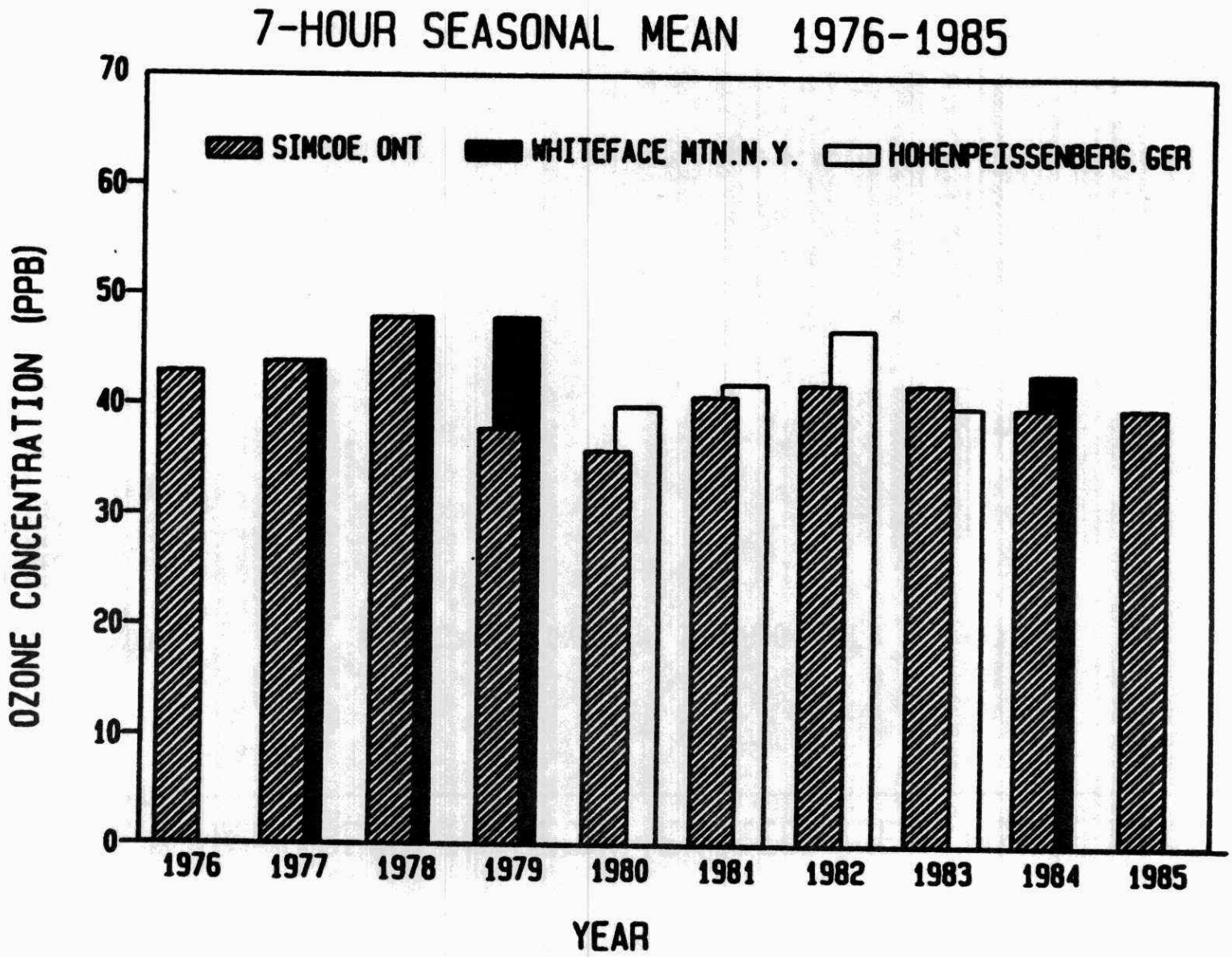
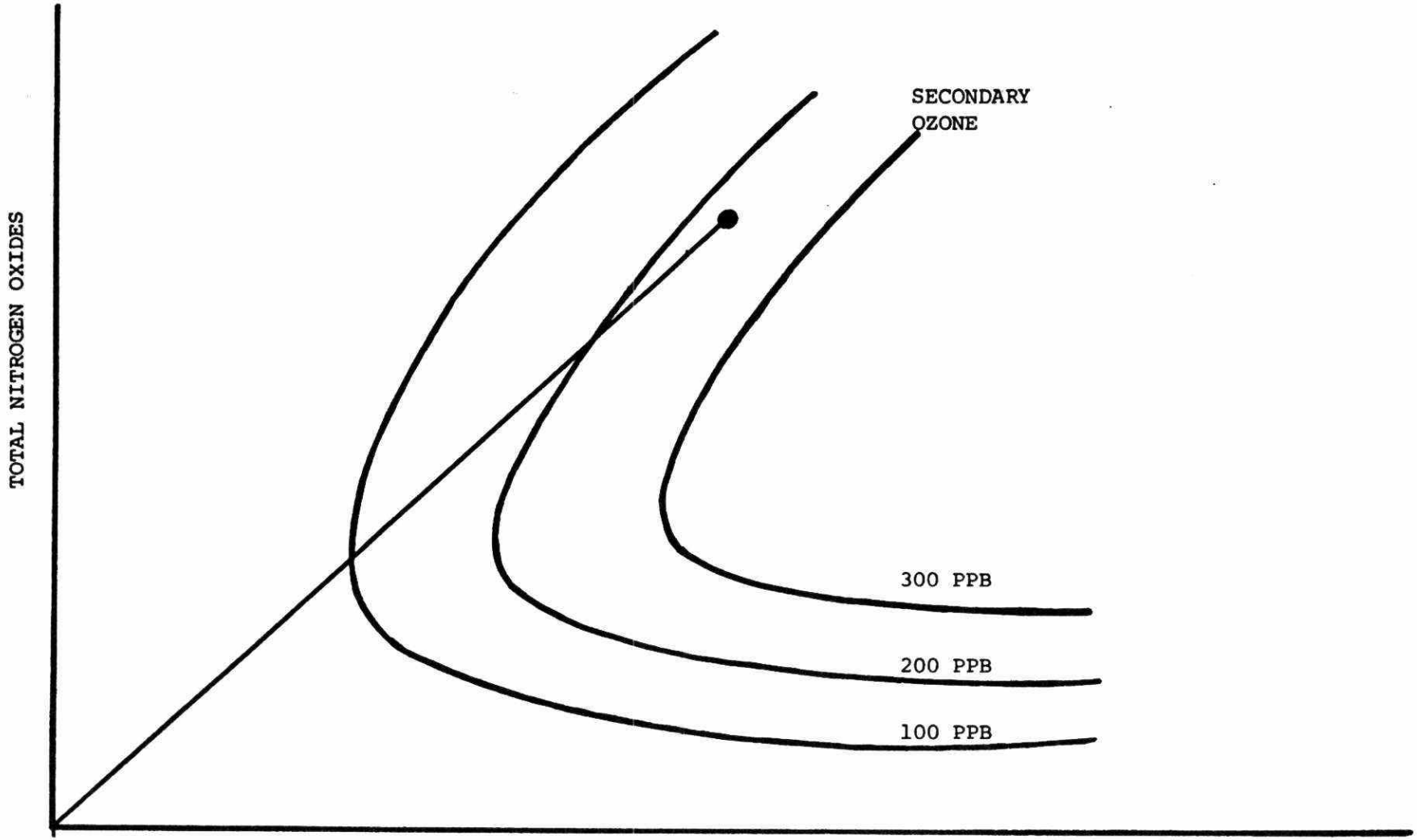

7-HOUR SEASONAL MEAN 1976-1985
SIMCOE, ONT
WHITEFACE MTN.N.Y.
HOHENPEISSENBERG, GER
OZONE CONCENTRATION (PPB)
70
60
50
40
30
20
10
0
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
YEAR

FIGURE 11

O_3 - NO_x - NMHC RELATIONSHIP FROM EKMA MODEL (US EPA)



A NEW AIR QUALITY INDEX FOR ONTARIO

by

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Introduction:

The Province of Ontario currently determines an Air Pollution Index (API) so that abatement action may be taken when levels of sulphur dioxide and suspended particulate matter (soiling index) approach concentrations which are potentially hazardous to the health of the population. These two pollutants which are mainly emitted by industrial sources, were chosen in 1970 because health studies showed a definite correlation between respiratory illness and high concentrations of these pollutants. In recent years attention has turned to other measured pollutants that are occurring in Ontario at concentrations higher than Ontario's desirable criteria. Some of these such as ozone, are transported into Southern Ontario from outside the Province.

In order to better inform the public on the current quality of Ontario's air, a new Air Quality Index (AQI) has been developed. The New Index includes the pollutants upon which the API is based, as well as other presently measured pollutants such as, carbon monoxide, ozone, nitrogen dioxide and total reduced sulphur compounds, for which there is evidence that adverse effects to the environment occur at known ambient concentrations. The AQI Information System will inform the public on the quality of the air on a real-time basis. To provide this service to all major cities in the Province, a new air quality telemetry system has been installed. The system is now being tested and debugged.

Index Design Criteria:

The new Air Quality Index was designed to have the following attributes:

1. be readily understandable by the public;
2. be consistent with perceived air quality;
3. include any measured pollutant or combination of pollutants for which there are criteria on effects;

4. be expandable in the future to pollutants not presently measured or for which criteria are at present unavailable;
5. be consistent in meaning with the numerical values of our present Air Pollution Index system.

The Design of Index:

The new Ontario Air Quality Index is similar in design to that of the National Index of the Quality of Air issued in Alberta and New Brunswick and that of the U.S.-E.P.A. Pollutant Standards Index (U.S.-P.S.I.) issued for most American Cities. Our Index differs from the former in order to be completely compatible with our A.P.I. The Index differs from the U.S. - P.S.I. in that the descriptive categories and numerical values are related to Canadian criteria and objectives for each of the pollutants. These differ from U.S. standards.

In each case a Sub-Index ranging form zero upwards relates to the concentration of each of the pollutants. As the Sub-Index increases the air quality decreases. The Sub-Index is calculated for each pollutant based on its effects and the highest Sub-Index at any time becomes the Air Quality Index.

The Index values are divided into five descriptives categories as follows:

Very Good (0-15) Air quality levels that meet long term goals, normally occurring in areas having a pristime environment with no local man-made sources of atmospheric pollutants.

Good (16-31) Air quality levels that have no known adverse effects to human or animal health and negligible effects on vegetation, property or aesthetic values.

Moderate (32-49) Air quality levels that have negligible effects on human or animal health but may adversely effect very sensitive vegetation, property or aesthetic values.

Poor (50-99) Air quality levels that may have adverse effect to sensitive members of human or animal population, or may cause significant damage to vegetation, property, or aesthetic values.

Very Poor (≥100) Air quality levels that may cause adverse effects to the health of large segments of the exposed population.

The impact of each pollutant are different in each category as shown in the matrix given in Fig. 1.

The Basis for Sub-Index Levels by Pollutant

The Air Pollution Index which is based on the 24-hour average concentration of sulphur dioxide and suspended particulate matter becomes one of the Sub-Indices. The Alert System, whereby Ontario's industrial sources are curtailed when levels of the API exceed 32, will continue as per Ontario's Regulation.

Additional Sub-Indices will be calculated using the information in the following table. The graphs in Figs. 2-8 illustrate the relationship between the Sub-Index and the pollutant concentrations.

Sulphur Dioxide - 1 hour average

Very Good - 0 to 0.16 ppm (Max. Desirable Level)
Good - 0.17 to 0.25 ppm (Ontario Criterion)
Moderate - 0.26 to 0.34 ppm (Max. Acceptable Level)
Poor - 0.35 to 1.99 ppm (Prudent level set for safety)
Very Poor ≥2.00 ppm

Coefficient of Haze (Suspended Particulate) - 1 hour average

Very Good - 0 - 1.0 COH
Good - 1.1 - 1.9 COH
Moderate - 2.0 - 3.9 COH
Poor - 4.0 - 5.9 COH
Very Poor ≥6.0

Carbon Monoxide - 1 hour average

Very Good - 0 - 12 ppm (Max. Desirable Level)
Good - 13 - 22 ppm (Extrapolated)
Moderate - 23 - 30 ppm (Ontario criterion and Max. Acceptable Level)
Poor - 31 -49 ppm (equiv. effect as Max. Tol. Level established for 8 hrs, 18 ppm)
Very Poor ≥50 ppm

Carbon Monoxide - 8 hour average

Very Good - 0 - 5 ppm (Max. Desirable Level)
Good - 6 - 9 ppm (extrapolated)
Moderate - 10 - 13 ppm (Max. Acceptable Level)
Poor - 14 - 17 ppm (Max. Tolerable Level)
Very Poor ≥18 ppm

Nitrogen Dioxide - 1 hour average

Very Good - 0 - 0.10 ppm (no effects)
Good - 0.11 - 0.20 ppm (Ont. Desirable Criterion & Max. Acceptable Level)
Moderate - 0.21 - 0.25 ppm (extrapolated)
Poor - 0.26 - 0.52 ppm (Max. Tolerable Level)
Very Poor ≥0.53 ppm

Ozone - 1 hour average

Very Good - 0 - 0.050 (Max. Desirable)
Good - 0.051 - 0.080 ppm (Ont. criterion)
Moderate - 0.081 - 0.120 ppm (U.S. - E.P.A. Std.)
Poor - 0.121 - 0.199 ppm (Max. Tol. Level)
Very Poor ≥0.200 ppm

Total Reduced Sulphur - 1 hour average

Very Good - 0 - 0.005 ppm
Good - 0.006 - 0.010 ppm (Ont. Criterion for Methyl Mercaptan)
Moderate - 0.011 - 0.027 ppm (Ont. Criterion for TRS emitted by pulp mills)
Poor - 0.028 - 0.999 ppm (Max. Tol. Level)
Very Poor ≥1.00 ppm

Index Cities

The new A.Q.I. will be issued for each of the 7 locations for which the API is presently reported: Toronto, Hamilton, Windsor, Sarnia, Sudbury, St. Catharines and Niagara Falls, as well as the following locations: London, Kitchener, Waterloo, Guelph, Burlington, Oakville, Oshawa, Mississauga, Sault Ste. Marie, Thunder Bay, North Bay, Cornwall, Ottawa and Kingston.

In the larger urban areas such as Toronto and Hamilton there will be more than one Index station, each representative of the air quality of the area in which it is located.

Based on the measured concentrations of each pollutant during years 1984 and 1985 at air monitoring stations in many of the above noted cities, the frequency of the number of hours that the categories Moderate and Poor occurred were computed. There were no occurrences of the Very Poor category. There were very few hours when Poor conditions were recorded. At all locations monitored, the air quality was Good or better over 90% of the time as shown in the following Tables.

HOURS OF MODERATE AND POOR AQI CATEGORY 1984

			API	O_3	COH	SO_2	NO_2	CO(8)	CO(1)	TRS	AQI
Windsor	(12008)	Mdt.	0	137	66	0	0	0	0	*	203
		Poor	0	2	0	0	0	0	0	*	2
Windsor	(12016)	Mdt.	18	*	53	0	*	*	*	*	68
		Poor	0	*	0	0	*	*	*	*	0
Sarnia	(14064)	Mdt.	0	78	5	1	0	0	0	25(4)	109
		Poor	0	2	0	0	0	0	0	2(4)	4
London	(15001)	Mdt.	0	24	9	0	0	0	0	*	33
		Poor	0	0	0	0	0	0	0	*	0
St. Catharines	(27037)	Mdt.	0	19	13	0	0	0	0	*	32
		Poor	0	0	0	0	0	0	0	*	0
Hamilton	(29008)	Mdt.	134	*	186	0	0	0	0	6	303
		Poor	0	*	0	0	0	0	0	3	3
Hamilton	(29025)	Mdt.	125	7	138	0	0	0	0	132	350
		Poor	0	0	1	0	0	0	0	6	7
Toronto	(31104)	Mdt.	0	44	33	0	0	0	0	*	77
		Poor	0	1	0	0	0	0	0	*	1
Scarborough	(33003)	Mdt.	0	16	19	0	0	0	0	*	35
		Poor	0	1	0	0	0	0	0	*	1
North York	(34007)	Mdt.	30	*	209	0	1	0	0	*	220
		Poor	0	*	0	0	0	0	0	*	0
Etobicoke	(35033)	Mdt.	15	7	83	0	0	0	0	*	100
		Poor	0	0	0	0	0	0	0	*	0
Oakville	(44015)	Mdt.	0	14	34	0	0	0	0	223	264
		Poor	0	0	0	0	0	0	0	9	9
Oshawa	(45025)	Mdt.	0	2	45	0	0	0	0	*	47
		Poor	0	0	0	0	0	0	0	*	0
Ottawa	(51001)	Mdt.	0	7	1	0	0	0	0	*	8
		Poor	0	0	0	0	0	0	0	*	0
Cornwall	(56051)	Mdt.	0	19	0	0	0	0	0	117	136
		Poor	0	0	0	0	0	0	0	20	20
Sudbury	(77016)	Mdt.	0	0	6	9	0	0	0	*	15
		Poor	0	0	0	5	0	0	0	*	5
Thunder Bay	(63040)	Mdt.	0	0	0	0	*	*	*	*	0
		Poor	0	0	0	0	*	*	*	*	0

* = Pollutant not measured
(4) = Four months data only

HOURS OF MODERATE AND POOR AQI CATEGORY 1985

			API	O_3	COH	SO_2	NO_2	CO(8)	CO(1)	TRS	AQI
Windsor	(12008)	Mdt.	0	77	22	0	0	0	0	*	99
		Poor	0	0	0	0	0	0	0	*	0
Windsor	(12016)	Mdt.	0	*	15	0	*	*	*	*	15
		Poor	0	*	0	0	*	*	*	*	0
Sarnia	(14064)	Mdt.	0	47	1	0	0	0	0	16	64
		Poor	0	0	0	0	0	0	0	1	1
London	(15001)	Mdt.	0	31	10	0	0	0	0	*	41
		Poor	0	0	1	0	0	0	0	*	1
St. Catharines	(27037)	Mdt.	0	19	3	0	0	0	0	*	22
		Poor	0	0	0	0	0	0	0	*	0
Hamilton	(29025)	Mdt.	23	17	75	0	0	0	0	111	193
		Poor	0	0	1	0	0	0	0	5	6
Toronto	(31104)	Mdt.	0	27	3	0	0	0	0	*	30
		Poor	0	0	0	0	0	0	0	*	0
Scarborough	(33003)	Mdt.	0	0	7	0	0	0	0	*	7
		Poor	0	0	0	0	0	0	0	*	0
North York	(34007)	Mdt.	0	*	43(4)	0	0	0	0	*	43
		Poor	0	*	0	0	0	0	0	*	0
Etobicoke	(35033)	Mdt.	0	14	55	0	0	0	0	*	69
		Poor	0	0	0	0	0	0	0	*	0
Oakville	(44015)	Mdt.	0	12	9	0	0	0	0	124	141
		Poor	0	0	0	0	0	0	0	8	8
Oshawa	(45025)	Mdt.	0	42	54	0	0	0	0	*	94
		Poor	0	0	0	0	0	0	0	*	0
Ottawa	(51001)	Mdt.	0	1	0	0	0	0	0	*	1
		Poor	0	0	0	0	0	0	0	*	0
Cornwall	(56051)	Mdt.	0	1	5	0	0	0	0	68	74
		Poor	0	0	0	0	0	0	0	14	14
Sudbury	(77016)	Mdt.	5	1	2	17	0	0	0	*	24
		Poor	0	0	0	12	0	0	0	*	12
Thunder Bay	(63040)	Mdt.	0	0	0	0	*	*	*	*	0
		Poor	0	0	0	0	*	*	*	*	0

* - Pollutant not measured
(4) - Four months data only

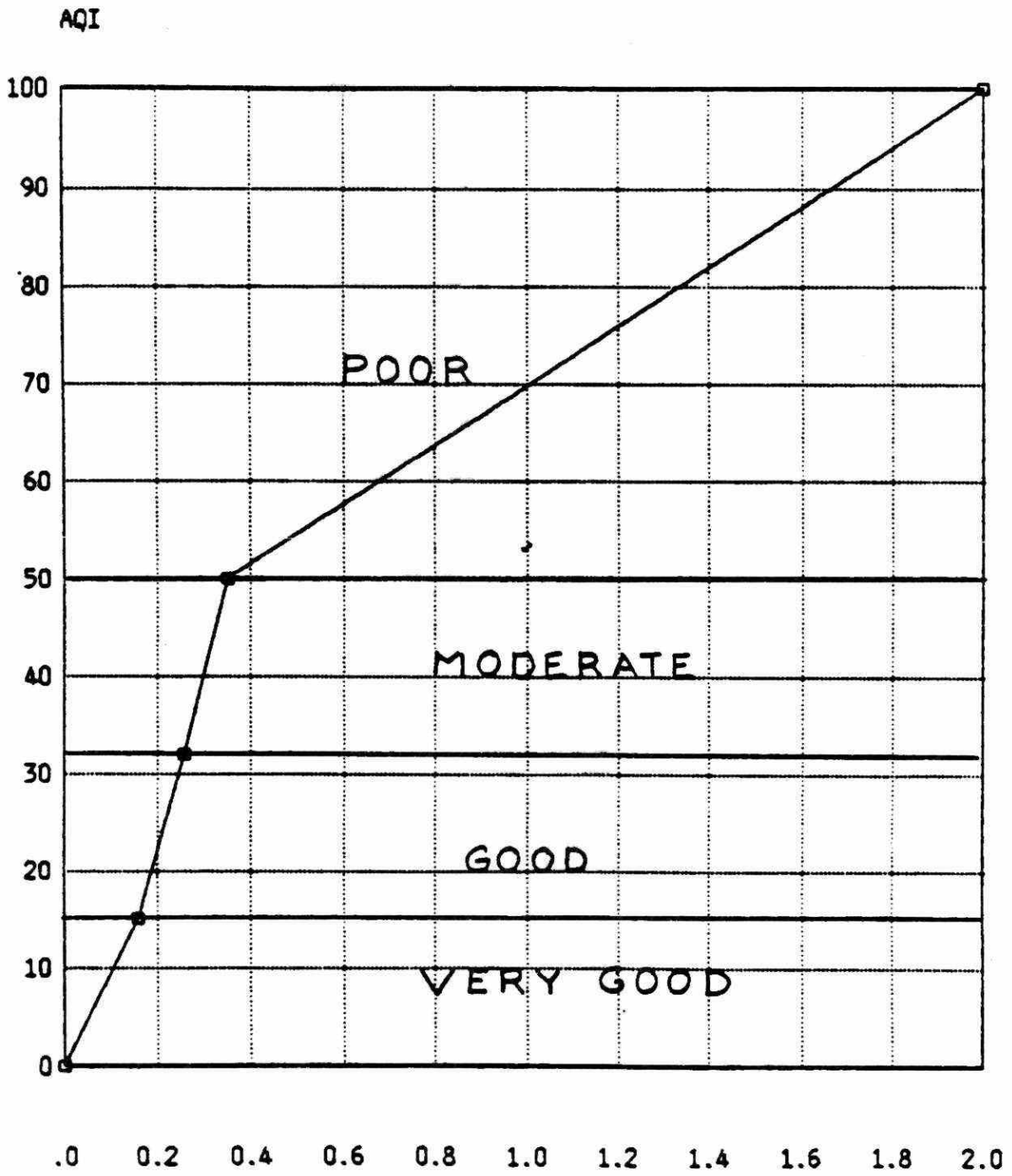
POLLUTANTS AND THEIR IMPACT

INDEX	CATEGORY	CARBON MONOXIDE CO	NITROGEN DIOXIDE NO2	OZONE O3	SULPHUR DIOXIDE SO2	SUSPENDED PARTICLES COH	API SO2+COH	TOTAL REDUCED SULPHUR TRS
100-150	VERY POOR	INCREASING CARDIOVASCULAR SYMPTOMS ON NON-SMOKERS WITH HEART DISEASE. SOME VISUAL IMPAIRMENT	INCREASING SENSITIVITY OF PATIENTS WITH ASTHMA AND BRONCHITIS	LIGHT EXERCISE PRODUCES EFFECT ON PATIENTS WITH CHRONIC PULMONARY DISEASE	INCREASING SENSITIVITY ON PATIENTS WITH ASTHMA AND BRONCHITIS	INCREASING SENSITIVITY ON PATIENTS WITH ASTHMA AND BRONCHITIS	SIGNIFICANT EFFECTS ON PATIENTS WITH ASTHMA AND BRONCHITIS	SENSITIVE INDIVIDUALS MAY SUFFER NAUSEA AND HEADACHES DUE TO SEVERE ODOUR
50-99	POOR	INCREASED CARDIOVASCULAR SYMPTOMS ON SMOKERS WITH HEART DISEASE	ODOUR AND DISCOLORATION. SOME INCREASE IN BRONCHIAL REACTIVITY IN ASTHMATICS	DECREASING PERFORMANCE BY ATHLETES EXERCISING HEAVILY	ODOUROUS, INCREASING VEGETATION DAMAGE AND SENSITIVITY	VISIBILITY DECREASED. SOILING EVIDENT	INCREASED SYMPTOMS TO PATIENTS WITH CHRONIC RESPIRATORY DISEASE	EXTREMELY ODOUROUS
32-49	MODERATE	BLOOD CHEMISTRY CHANGES BUT NO DETECTABLE IMPAIRMENT	ODOUROUS	INJURIOUS TO MANY VEGETATION SPECIES E.G. WHITE BEANS, TOMATOES, ETC.	INJURIOUS TO SOME SPECIES OF VEGETATION	SOME DECREASE IN VISIBILITY	INJURIOUS TO VEGETATION DUE TO SULPHUR DIOXIDE	ODOUROUS
16-31	GOOD	NO EFFECTS	SLIGHT ODOUR	INJURIOUS TO SOME VEGETATION SPECIES IN COMBINATION WITH SO2(4 HRS)	INJURIOUS TO SOME VEGETATION SPECIES IN COMBINATION WITH OZONE(4 HRS)	NO EFFECTS	NO EFFECTS	SLIGHT ODOURS
0-15	VERY GOOD	NO EFFECTS	NO EFFECTS	NO EFFECTS	NO EFFECTS	NO EFFECTS	NO EFFECTS	NO EFFECTS

Figure 2

INDEX FOR SO2

(1 Hr. Avg.)



1 Hr. Avg. SO2

Figure 3

INDEX FOR COH

(1 Hr. Avg)

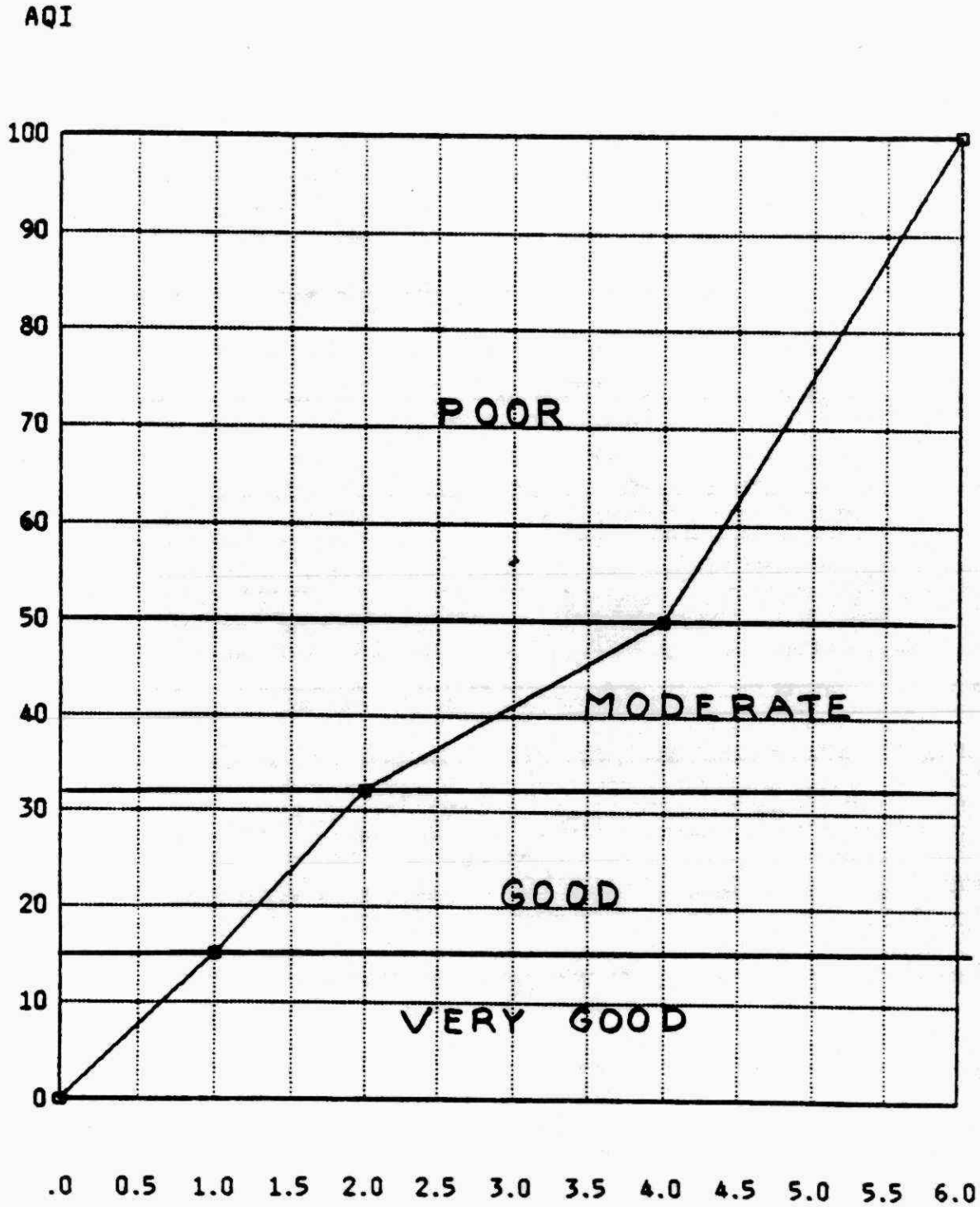
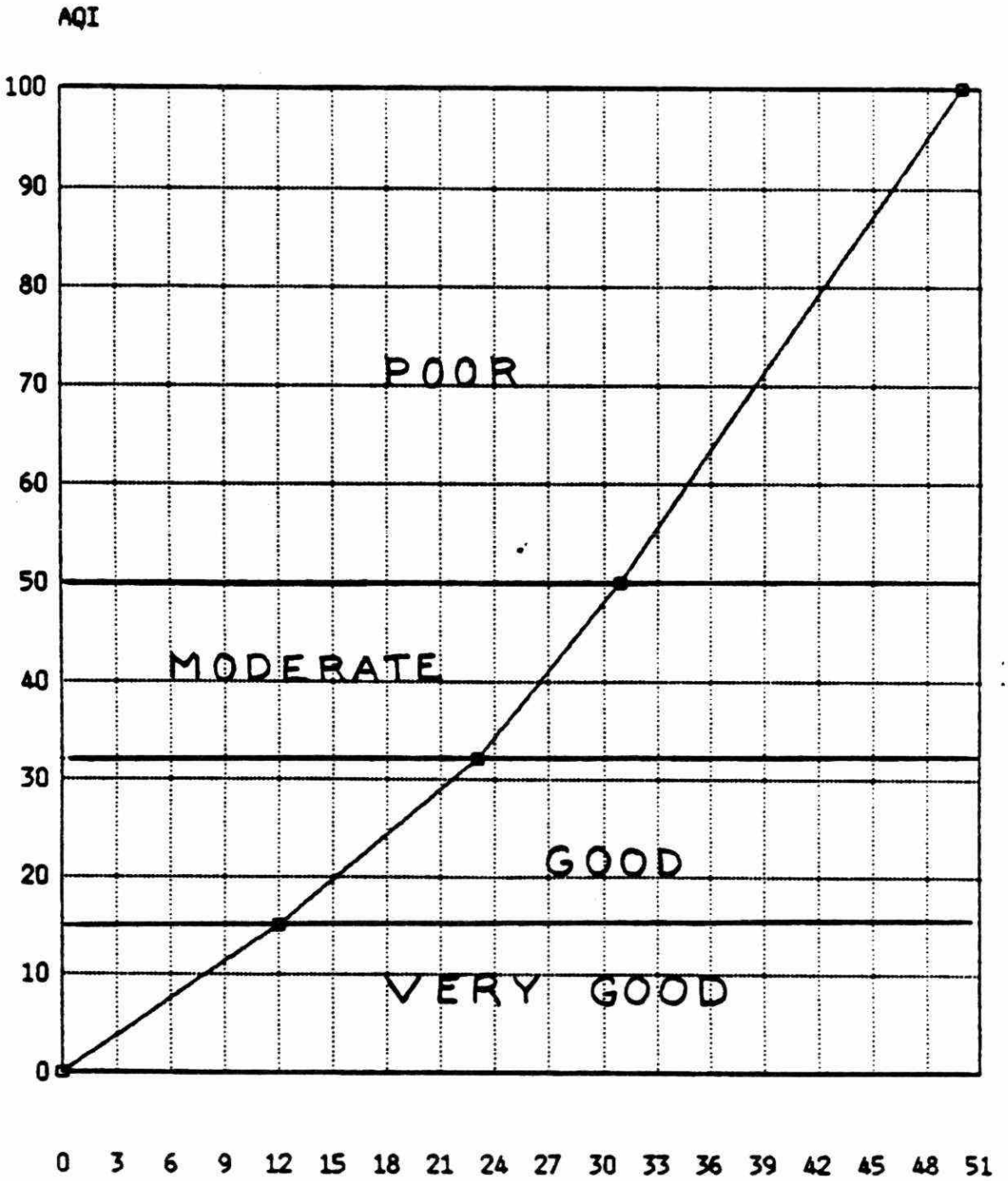


Figure 4

INDEX FOR CO

(1 Hr. Avg.)

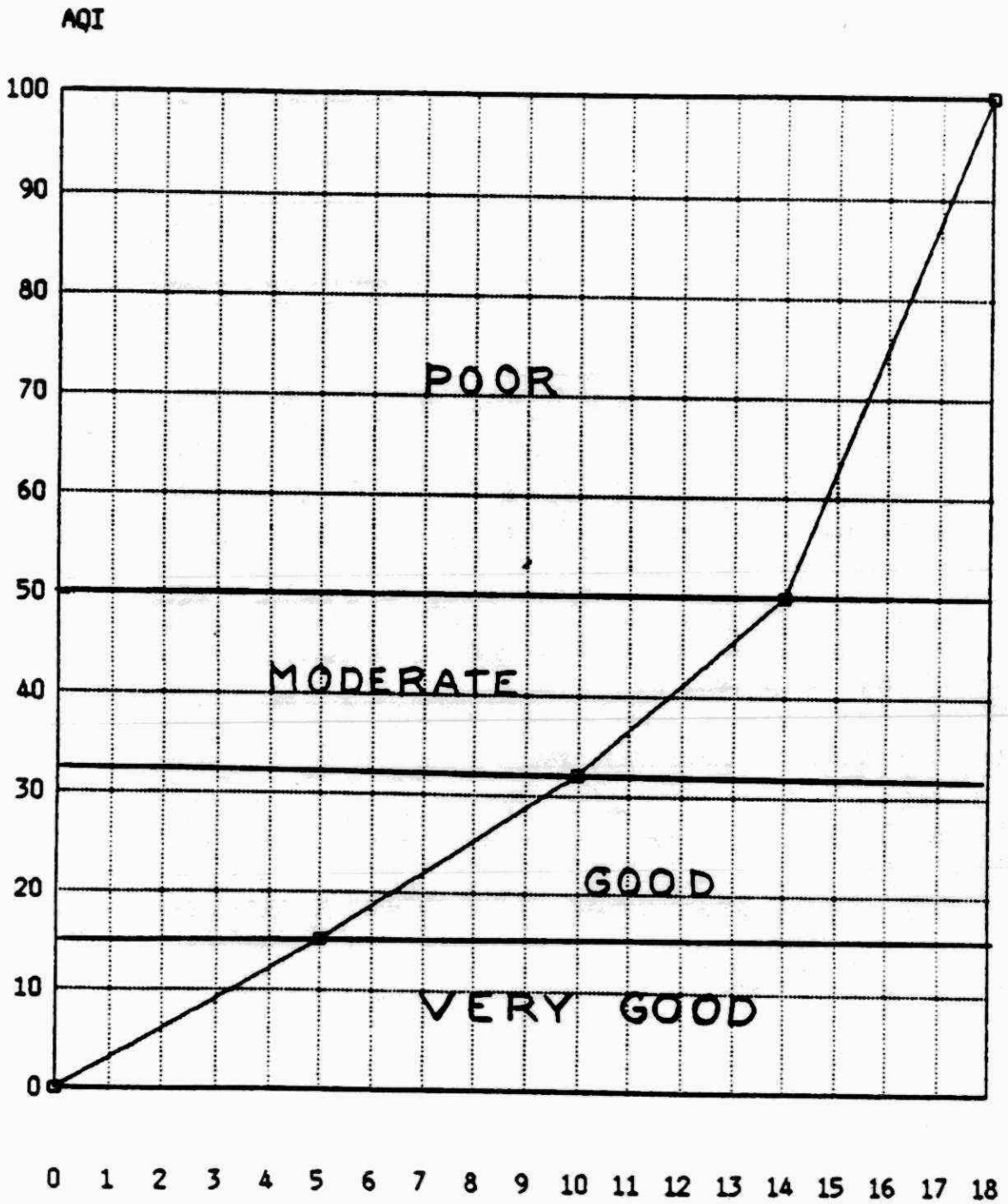


1 Hr. Avg. CO

Figure 5

INDEX FOR CO

(8 Hr. Avg.)

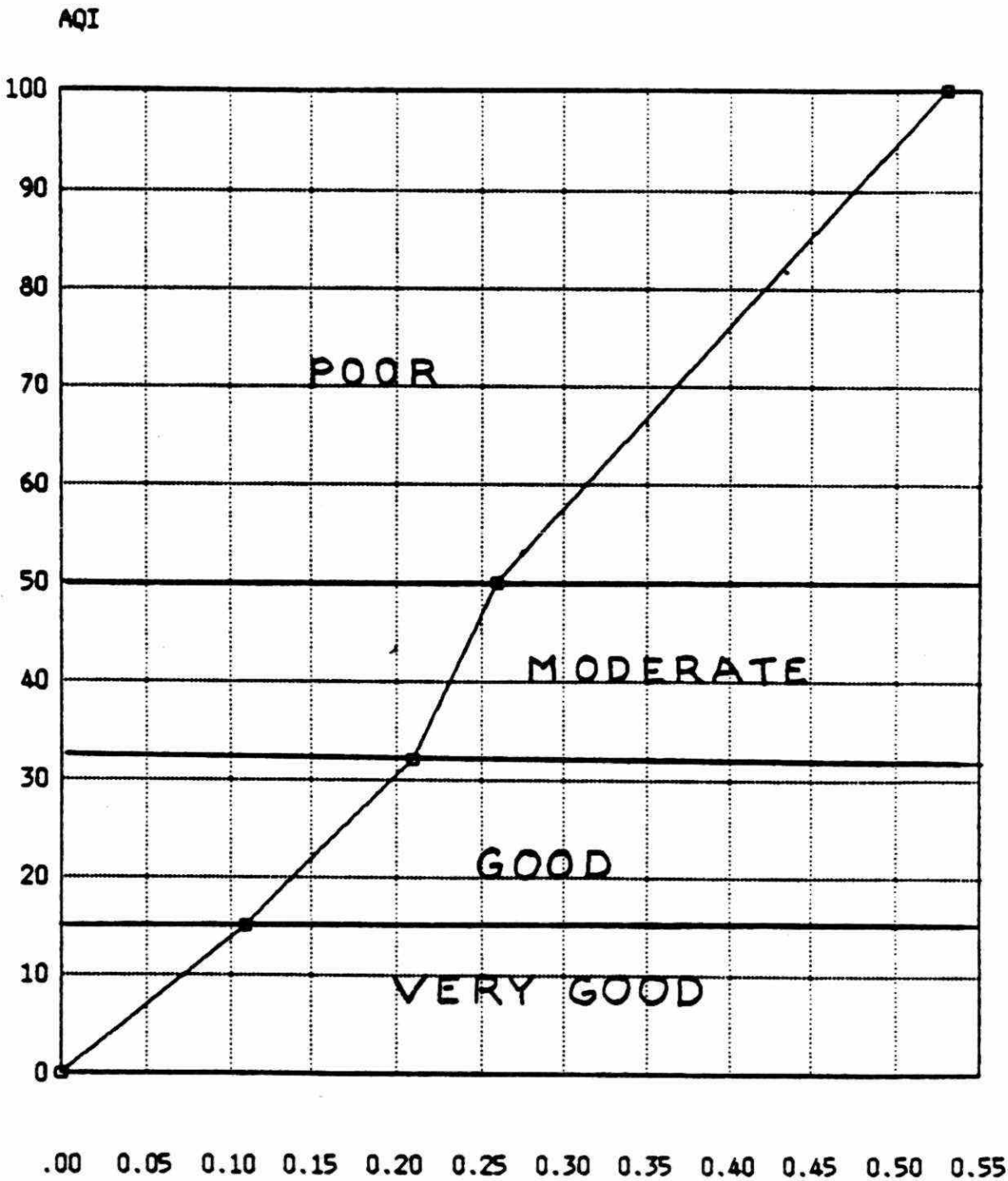


8 Hr. Avg. CO

Figure 6

INDEX FOR NO2

(1 Hr. Avg.)

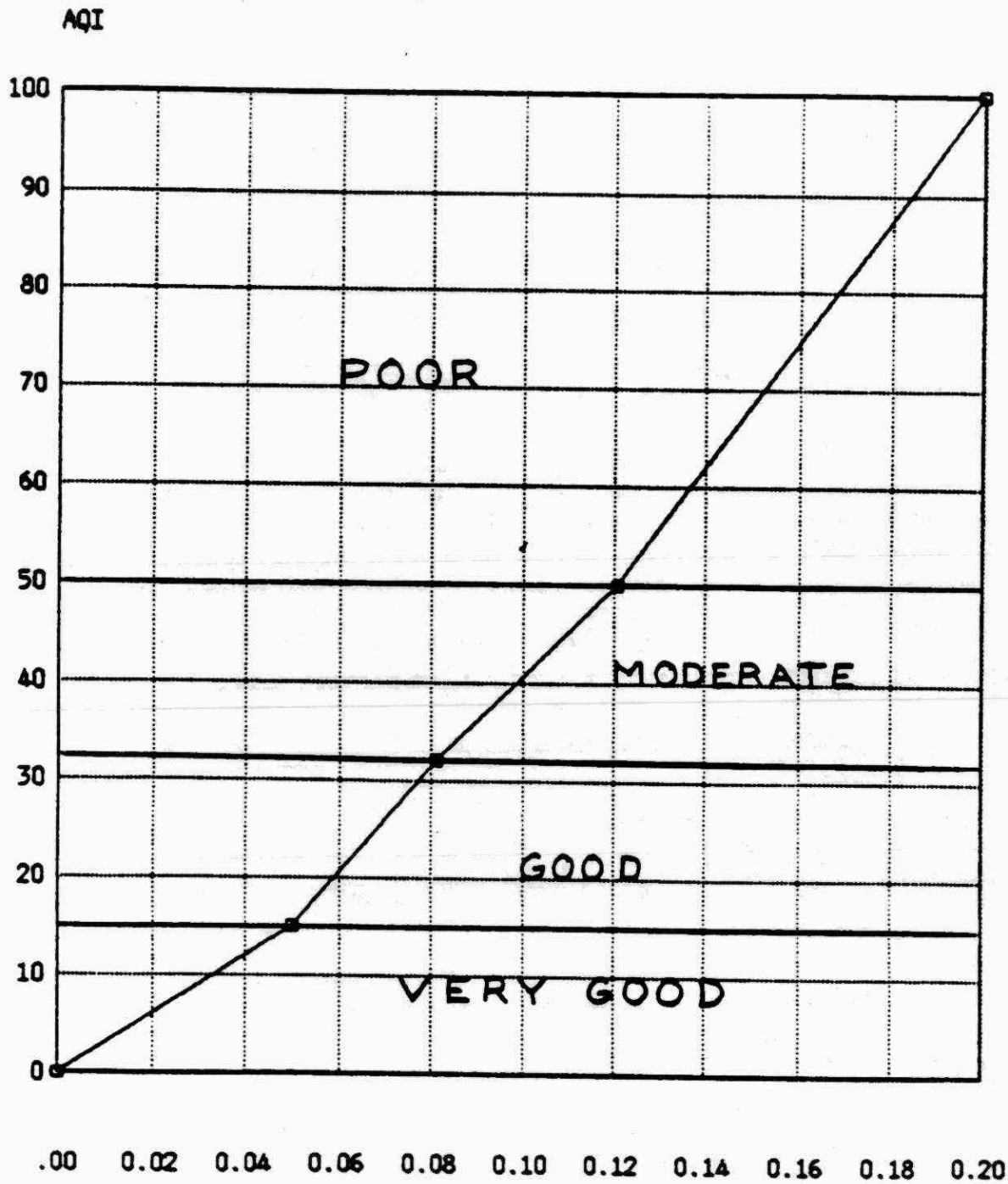


1 Hr. Avg. NO2

Figure 7

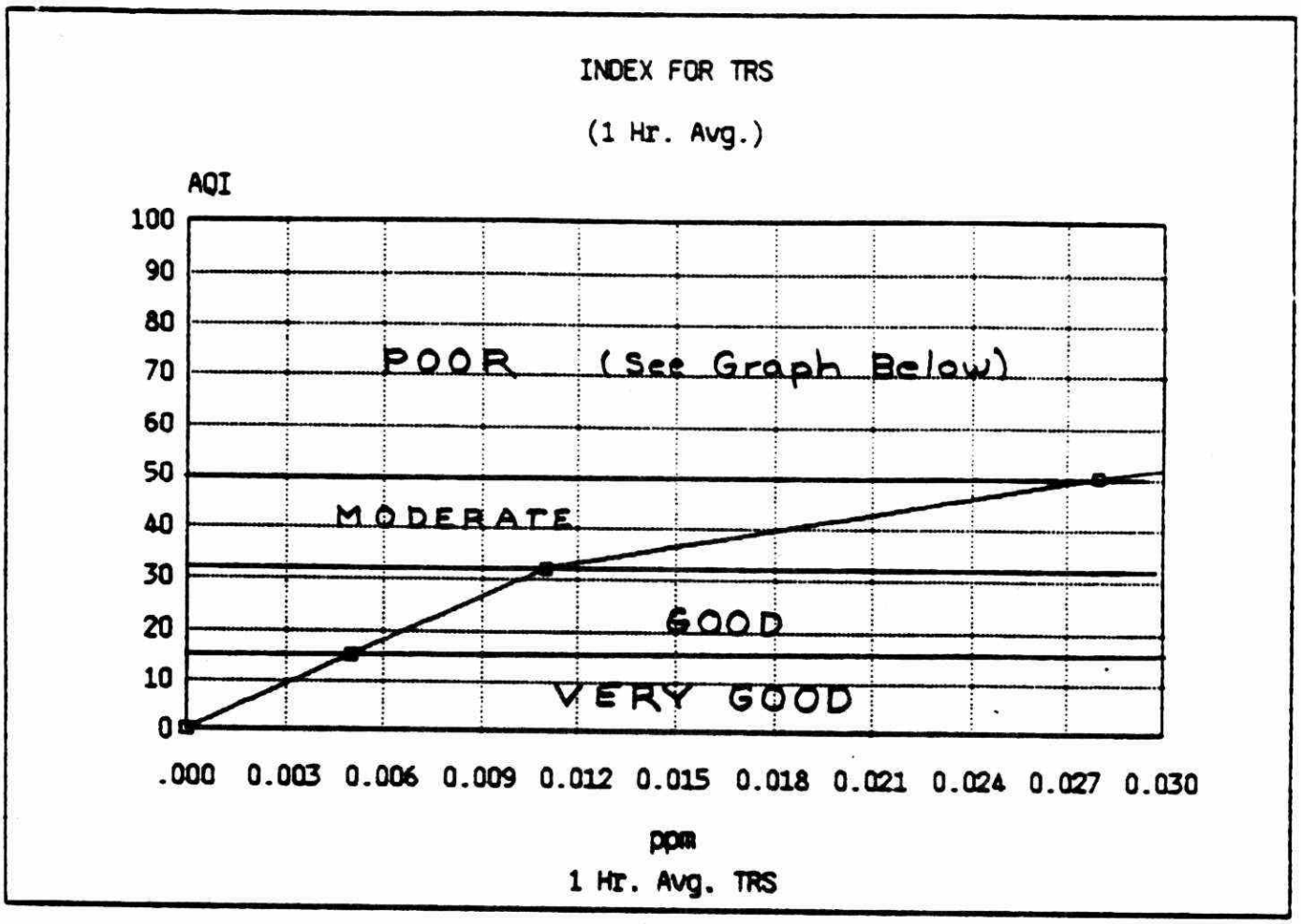
INDEX FOR O3

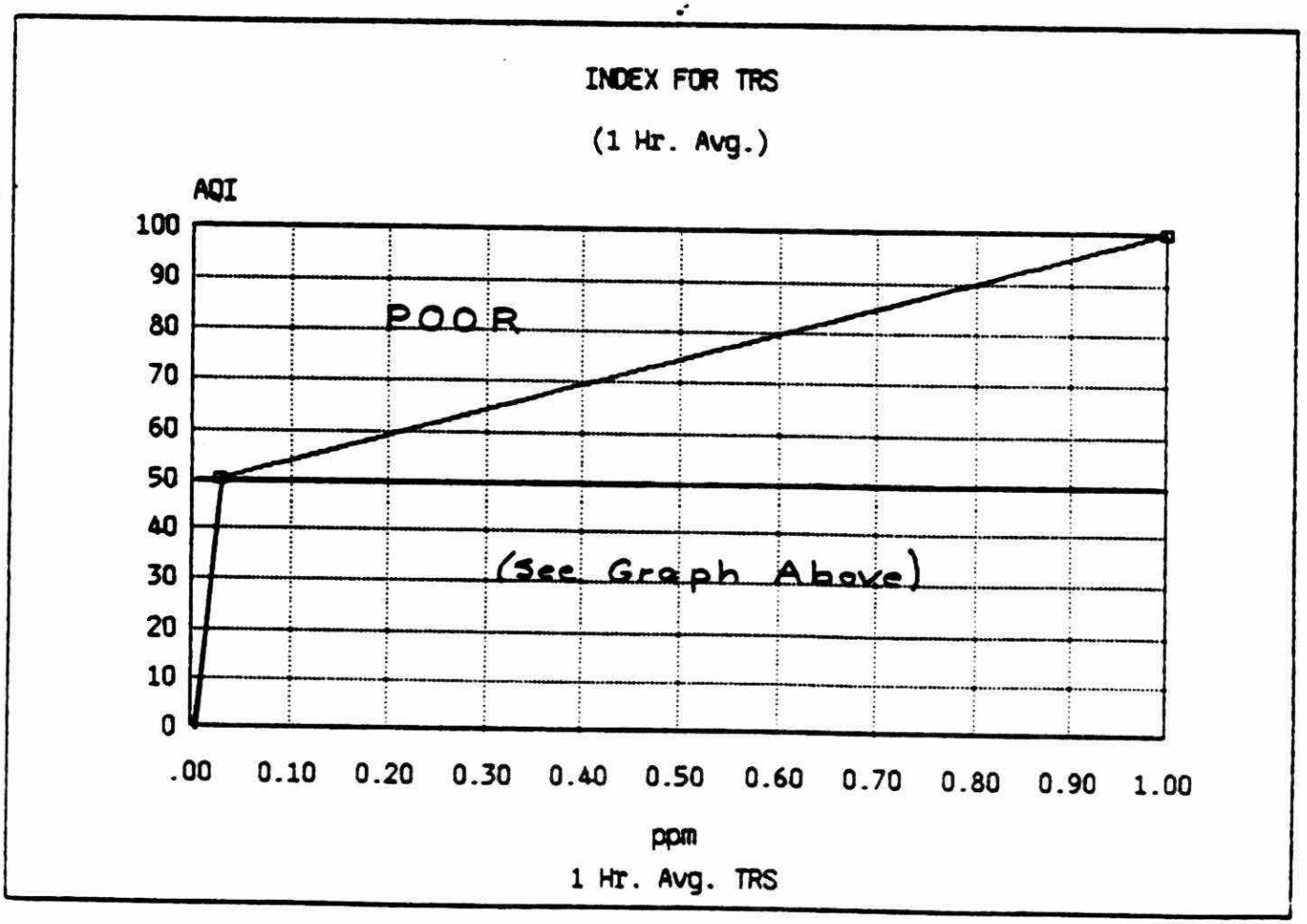
(1 Hr. Avg.)



1 Hr. Avg. O3

Figure 8


INDEX FOR TRS
(1 Hr. Avg.)
AQI
100
90
80
70
60
50
40
30
20
10
0
POOR (See Graph Below)
MODERATE
GOOD
VERY GOOD
.000 0.003 0.006 0.009 0.012 0.015 0.018 0.021 0.024 0.027 0.030
ppm
1 Hr. Avg. TRS


INDEX FOR TRS
(1 Hr. Avg.)
AQI
100
90
80
70
60
50
40
30
20
10
0
POOR
(See Graph Above)
.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00
ppm
1 Hr. Avg. TRS

ODOUR CONTROL IN THE AUTOMOTIVE INDUSTRY

by

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Windsor, Ontario

INTRODUCTION

ODOURS ARE THE MAJOR CAUSE OF PUBLIC COMPLAINTS IN NORTH AMERICA. THEY CREATE MORE EMOTIONAL RESPONSES THAN ANY OTHER CLASS OF AIR POLLUTANTS EVEN WITH THE CONSIDERABLE ADVANCES IN ENVIRONMENTAL ANALYTICAL TECHNIQUES, IDENTIFICATION AND CONTROL OF ODORANTS ARE VERY DIFFICULT TO ACHIEVE AND IN MANY CASES THE SUCCESS DEPENDS NOT ONLY ON ESTABLISHED ENGINEERING AND SCIENTIFIC PRINCIPLES, BUT ALSO THE INGENUITY AND EXPERIENCE OF THE INVESTIGATORS.

IN THE AUTOMOTIVE INDUSTRY, ODOURS HAVE BEEN OF AN INCREASING CONCERN SINCE THE EARLY EIGHTIES WITH THE INTRODUCTION OF THE NEW HIGH SOLIDS, BASE COAT/CLEAR COAT ENAMEL PAINTS.

IMMEDIATELY AFTER THEIR INTRODUCTION, COMPLAINTS OF PAINT ODOURS STARTED COMING IN FROM THE SURROUNDING COMMUNITIES AND IN OUR CASE EVEN A CITIZEN'S LIAISON COMMITTEE COMPRISED OF AN ONTARIO MEMBER OF PROVINCIAL PARLIAMENT, CITY COUNCILLOR, LOCAL MINISTRY OF THE ENVIRONMENT OFFICIALS, AREA RESIDENTS AND COMPANY REPRESENTATIVES WAS FORMED TO TRACK THE DEVELOPMENTS AND REPORT TO THE CITIZENS OF THE PROGRESS BEING MADE.

WITH THIS KIND OF ATTENTION TO THE PROBLEM, IT WAS IMPERATIVE FOR US IN THE AUTOMOTIVE SECTOR, TO ATTACK IT IMMEDIATELY AND HOPEFULLY COME TO A QUICK RESOLUTION.

HIGH SOLIDS PAINT TECHNOLOGY

IN 1977, THE ENVIRONMENTAL PROTECTION AGENCY (EPA) IN THE U.S. INTRODUCED REASONABLY AVAILABLE CONTROL TECHNOLOGY (RACT) GUIDELINES TO LIMIT THE AMOUNTS OF VOLATILE ORGANIC COMPOUNDS (VOC) BEING EMITTED BY PAINTING OPERATIONS. THE RACT NUMBERS WERE WRITTEN IN TERMS OF WEIGHT OF POUNDS OF VOC'S PER GALLON OF COATINGS.

THE COATING INDUSTRY'S REACTION WAS TO FORMULATE COMPLIANCE COATINGS UTILIZING NEW PAINT TECHNOLOGY WHICH RESULTED IN:

- HIGHER SOLIDS CONTENT
- FEWER VOC'S BEING RELEASED
- HIGHER TRANSFER RATES
- HIGH GLOSS FINISHES WITH BASE COAT/CLEAR COAT SYSTEM

THIS NEW HIGH SOLIDS PAINT TECHNOLOGY REQUIRED THE USE OF DIFFERENT SOLVENTS THAN HAD PREVIOUSLY BEEN EMPLOYED IN THE LOW SOLIDS FORMULATIONS.

THESE NEW SOLVENTS HAD TO MEET THE FOLLOWING PERFORMANCE CRITERIA:

- STRONG SOLVENCY
- LOW VOLATILITY
- HIGH RESISTIVITY
- LOW DENSITY
- LOW HEALTH HAZARD

THIS RESULTED IN THE DEVELOPMENT AND USAGE OF OXYGENATED SOLVENTS, HIGH-BOILING ALKYL ACETATES OF PRIMARY ALCOHOLS, KETONES AND GLYCOL ETHER ACETATES. HOWEVER, NOWHERE WAS THERE A REQUIREMENT FOR LOW ODOUR.

ODOUR PROBLEM

CHRYSLER WAS ONE OF THE FIRST AUTOMOTIVE MANUFACTURERS TO INTRODUCE THE NEW BASE COAT/CLEAR COAT ACRYLIC ENAMEL PAINT TECHNOLOGY INTO THE ASSEMBLY PLANTS. BY EARLY 1984 IT BECAME APPARENT THAT THERE WERE SEVERE ODOUR PROBLEMS IN COMMUNITIES NEAR PLANTS WHICH PREVIOUSLY HAD NO HISTORY OF ODOUR COMPLAINTS AND THAT A CORRELATION EXISTED WITH THE NEW HIGH SOLIDS PAINT TECHNOLOGY.

PRELIMINARY NEIGHBOURHOOD ODOUR SURVEYS INDICATED THAT CHARACTERISTIC PAINT ODOURS WERE DETECTABLE UP TO FOUR MILES DOWN WIND OF AN ASSEMBLY PLANT AND THAT THE INTENSITY WAS UNACCEPTABLE TO RESIDENTS WITHIN A MILE OF THE FACILITY.

NOT ONLY WAS THIS A VERY PERVASIVE ODOUR, BUT IT WAS ALSO CHARACTERIZED AS HAVING A "MUSHROOM" LIKE SMELL WHICH COULD NOT BE PINNED DOWN TO ANY SPECIFIC SOURCE OR COMPOUND IN THE PAINT FORMULATION.

THE SOLVENTS EMPLOYED PREVIOUSLY IN THE LOW SOLIDS TECHNOLOGY WERE SIMILAR TO THE COMPONENTS IN GASOLINE AND ALTHOUGH THEY HAVE THE CHARACTERISTIC SOLVENT ODOURS, THEY CERTAINLY WERE NOT PERVASIVE TO THIS EXTENT.

TO DETERMINE THE ORIGIN OF THE MALODOUR, A GROUP OF PEOPLE WERE CHOSEN FOR AN ODOUR PANEL WHO HAD ODOUR DETECTION CAPABILITIES ABOVE AND BELOW THE AVERAGE PERSON SO THAT THE PANEL WOULD BE REPRESENTATIVE OF THE AVERAGE AREA RESIDENTS.

SAMPLES WERE COLLECTED FROM A VARIETY OF SOURCES INCLUDING PAINT SPRAY BOOTH EXHAUSTS AND PAINT OVEN EXHAUSTS. THESE WERE PRESENTED TO THE ODOUR PANEL THROUGH A DYNAMIC DILUTION FORCED-CHOICE TRIANGLE OLFACTOMETER AT DIFFERENT DILUTIONS.

EACH PANELIST IS GIVEN 3 CHOICES IN EACH HOLDER. ONE IS A DILUTION OF THE SAMPLE AND THE OTHER TWO ARE BLANKS. BY CHOOSING ONE OF THE STREAMS AT VARIOUS DILUTIONS, IT IS POSSIBLE TO DETERMINE AT WHAT CONCENTRATION A PANELIST CAN DETECT THE ODOUR.

BY USING A STATISTICAL PROCEDURE FOR ANALYZING THE DATA FROM ALL PANELISTS, AND ED_{50} FOR THAT SAMPLE CAN BE OBTAINED. THE ED_{50} IS THE EFFECTIVE DOSAGE AT WHICH ONE HALF THE PEOPLE ON THE PANEL CAN DETECT ODOUR AND THE OTHER HALF CAN'T DETECT IT. **(TABLE #1)**

IT BECAME OBVIOUS ON TABULATION OF THE ODOUR DATA THAT THE SPRAY BOOTH EXHAUST STACKS WERE THE PRIME SOURCE OF ODOUR IMPINGEMENT ON THE SURROUNDING COMMUNITY. THE 64 SPRAY BOOTH EXHAUSTS WITH A TOTAL OF 1,600,000 ACFM RESULTED IN OVER 90% OF THE ODOUR BEING EMITTED. BY CONTRAST THE PAINT OVEN EXHAUSTS ACCOUNTED ONLY FOR 5% OF THE TOTAL ODOUR EMITTED.

TABLE #1

EVALUATION FORM
DYNAMIC TRIANGLE OLFACTOMETER

SAMPLE : D EVALUATION DATE : 3-24-87

	PANELIST	DILUTION LEVEL NUMBER					
		1	2	3	4	5	6
		Correct Choice Would Be: (T) = Top C = Center B = Bottom					
1	Steve	T	B	C	(T)	T	T
2	Ray	C	T	B	(T)	T	T
3	Brenda	T	B	(T)	T	T	T
4	Frank	C	(T)	T	T	T	T
5	Dennis	C	(T)	T	T	T	T
6	Jean	C	B	C	(T)	T	T
7	Jeff	B	C	B	(T)	T	T
8	Chuck	C	(T)	T	T	T	T
Frequency Tally		0	3	1	4	0	0

RESULT: ED_{50} = 339 DILUTIONS

ED_{50} = 1.60 p.p.m WT.

PH8

A BRIEF DESCRIPTION OF THE PAINTING OPERATIONS IN AN AUTOMOTIVE ASSEMBLY PLANT IS AS FOLLOWS: AFTER THE BODY HAS BEEN ASSEMBLED, THE VEHICLE RECEIVES A ZINC PHOSPHATE COATING IN AN EIGHT-STAGE PHOSPHATE MACHINE; THEN THE VEHICLE IS IMMERSED IN A 90,000 GALLON TANK OF PRIMER PAINT CALLED UNIPRIME WHERE THE PAINT IS ELECTROCOATED ONTO THE VEHICLE. AFTER BAKING AND SANDING, THE BODY IS SPRAYED ON THE INTERIOR WITH BASE COAT PAINT BY FULLY AUTOMATIC ROBOTS. THE EXTERIOR IS THEN COATED WITH COLOURED BASE COAT PAINT BY BOTH AUTOMATIC AND MANUAL SPRAYS. THE CLEAR COAT IS THEN APPLIED DIRECTLY OVER THE WET BASE COAT USING HIGH VOLTAGE ELECTROSTATIC SPRAYS (HVES). THE TRANSFER EFFICIENCY OF GETTING PAINT SOLIDS ONTO THE VEHICLE IS ONLY 45% FOR THE BASE COAT BUT OVER 80% FOR THE HVES. THE OVERSPRAY PAINT SOLIDS AND ASSOCIATED VAPORIZED SOLVENT ARE DRAWN THROUGH THE WATER SCRUBBER WHICH EXTRACTS THE SOLID PAINT PARTICULATES. THE SOLVENTS ARE ONLY MINIMALLY EXTRACTED AND THE MAJORITY ARE EXHAUSTED ABOVE THE SPRAY BOOTH. BECAUSE THE AIR IS ONLY USED ONCE, AUTOMOTIVE SPRAY BOOTHS CONSUME HUGE QUANTITIES OF AIR - TYPICALLY 500,000 CFM PER BOOTH.

METHYL AMYL KETONE (MAK) REMOVAL

WHEN THE ODOUR PROBLEM WAS ESTABLISHED AS COMING FROM THE PAINT SOLVENTS, A DETAILED SURVEY OF ALL THE COMPONENTS OF THE PAINT FORMULATION WAS OBTAINED FROM THE SUPPLIER PPG. A COMPREHENSIVE LITERATURE SEARCH OF ALL THE ODOUR THRESHOLDS WAS ALSO COMPLETED TO ESTABLISH A RANKING OF ODOUR CONTRIBUTION OF EACH SOLVENT COMPONENT.

THIS THEORETICAL EXERCISE QUICKLY POINTED TO 2-HEPTANONE OR METHYL AMYL KETONE (MAK) AS BEING THE PRIMARY SUSPECT COMPONENT FOR CAUSING THE SIGNIFICANT INCREASE IN ODOUR. IT WAS ALSO ONE OF THE NEW SOLVENTS INTRODUCED WITH THE HIGH SOLIDS PAINT THAT HAD NOT BEEN USED PREVIOUSLY.

NEW FORMULATIONS MADE MINIMIZING THE USE OF MAK WERE DEVELOPED BY THE PAINT SUPPLIER IN THE LABORATORY AND WE FELT VERY CONFIDENT THAT INTRODUCTION OF THIS PAINT WAS THE ANSWER TO OUR ODOUR PROBLEMS.

CHRYSLER PRESENTED THIS PROGRAM OF REFORMULATION AT A PUBLIC MEETING OF AREA RESIDENTS, LOCAL POLITICIANS AND MOE REPRESENTATIVES IN SEPTEMBER 1984. RESIDENTS WERE ALSO CONCERNED ABOUT THE VARIOUS SUBSTANCES IN THE AMBIENT AIR AND DEMANDED THAT THE MOE BRING IN THEIR PORTABLE TAGA 3000 AMBIENT REAL TIME MONITORING VAN. SUBSEQUENT TESTING IN DECEMBER 1984, NOTED THE PRESENCE OF MAK IN THE AIR IN PARTS PER BILLION; HOWEVER, NONE OF THE COMPONENTS EXCEPT MAK EXCEEDED THE GOVERNMENT GUIDELINES FOR MAXIMUM GROUND LEVEL IMPINGEMENT.

THE MOE HAD SET A STANDARD MAXIMUM GROUND LEVEL CONCENTRATION FOR MAK AT 5 MICROGRAMS PER CUBIC METRE BASED ON THE PUBLISHED DATA ON ODOUR AND THE CHRYSLER ODOUR PROBLEMS.

MEANWHILE, THE MANUFACTURER OF THE SOLVENT WAS HEAVILY ENGAGED IN ODOUR TESTING AND IN RESEARCHING ALL THE ODOUR WORK WHICH HAD PREVIOUSLY BEEN PERFORMED ON MAK. THEY DISCOVERED THAT RESULTS OF THE ORIGINAL RESEARCH HAD BEEN TRANSFERRED INCORRECTLY INTO THE ASTM STANDARDS BY OVER 200 TIMES TOO SEVERE. THE MANUFACTURER HAD ASTM ACKNOWLEDGE THE ERROR AND CORRECT THE THRESHOLD VALUE IN FUTURE EDITIONS. WITH THIS TYPE OF PROBLEM IN PUBLISHED LITERATURE AND GIVEN THE CONCERN THAT OUR PARTICULAR SOLVENTS MAY HAVE DIFFERENT ODOUR THRESHOLDS, WE DECIDED TO TEST ALL PAINTS AND SOLVENT COMPONENTS.

FOR THE PAINT SUPPLIER TO EVALUATE THE INDIVIDUAL SOLVENTS IN THE SOLVENT PACKAGES, 3 INDEPENDENT U.S. ODOUR CONSULTANTS WERE RETAINED TO DEVELOP ED_{50}'S ON THE SPECIFIC COMPOUNDS. THE DATA RANGES WERE DEVELOPED AND WITH THIS INFORMATION THE SUPPLIER WAS ABLE TO FORMULATE LOWER ODOUR SOLVENT PACKAGES. FOR EACH FORMULATION CHANGE PRODUCTION TRIAL RUNS HAD TO BE CARRIED OUT IN THE PLANT TO ENSURE THAT THE GLOSS COLOUR, FILM BUILD PROPERTIES AND PRODUCTION APPLICATION TECHNIQUES WERE NOT AFFECTED. ALSO THE TOTAL OCCUPATIONAL EXPOSURE RISK HAD TO BE EQUAL OR LESS THAN PREVIOUS FORMULATIONS.

WITHIN A FEW MONTHS OF RESEARCH AND REFORMULATION, SUITABLE REPLACEMENTS FOR MAK WERE APPROVED FOR USE AND THE PROGRAM FOR REMOVAL WAS INITIATED.

BY EARLY SPRING OF 1985, 95% OF THE MAK HAD BEEN REMOVED FROM THE PAINT FORMULATIONS, BUT UNFORTUNATELY THE CHARACTERISTIC MUSHROOM SMELL WAS STILL PERVASIVE IN THE NEIGHBOURHOOD.

ODOUR ABATEMENT OF "MUSHROOM" SMELL

AT THE SAME TIME AS THE MAK REDUCTIONS WERE TAKING PLACE, CHRYSLER HAD RETAINED CLAYTON CONSULTANTS OF WINDSOR TO IDENTIFY THE COMPOUNDS IN THE AMBIENT AIR DOWNWIND OF THE PLANT AND TRY TO IDENTIFY WHICH ONES WERE NUISANCE ODOURS. THEY SAMPLED THE AIR BY ADSORBING THE COMPOUNDS ON TENEX TUBES FOR ONE-HALF HOUR.

THE SAMPLES WERE DESORBED AND ANALYZED BY GAS CHROMATOGRAPH AND MASS SPECTROMETER. OVER 34 COMPOUNDS WERE IDENTIFIED IN MINUTE QUANTITIES, SOME WERE KNOWN FROM THE SOLVENT FORMULATION, BUT OTHERS WERE EITHER FROM OTHER SOURCES OR ALREADY IN THE AMBIENT AIR.

TO IDENTIFY WHICH OF THESE COMPOUNDS WERE ODOROUS, DR. ALEX GNYP, A CHEMICAL ENGINEERING PROFESSOR AT THE UNIVERSITY OF WINDSOR AND A CONSULTANT TO CLAYTON, UTILIZED AN OLFACTROMETRIC TECHNIQUE WITH THE GAS CHROMATOGRAPH. THE INDIVIDUAL COMPONENTS WERE DIRECTED TO THE NOSE OF THE HUMAN OBSERVER AS THEY CAME OFF THE GC COLUMN. HE WOULD DESCRIBE THE OLFACTROMETRIC SENSATION OF EACH ODORANT AS HE PERCEIVED IT AND WOULD NOTE THE TIME OF THE OBSERVATION. EACH SAMPLE WOULD YIELD 25-30 ODOUR DESCRIPTORS OVER THE PERIOD OF THE GC ANALYSIS.

AT EXACTLY 17 MINUTES IN THREE SAMPLES THE DESCRIPTOR FOR MUSHROOM SMELL WAS NOTED: HOWEVER, BECAUSE OF THE TRACE QUANTITY IT COULD NOT BE DETECTED BY THE MASS SPECTROMETER AMONG ALL THE OTHER COMPOUNDS.

DR. GNYP SUGGESTED THAT WE LOOK AT THE VAPOUR PHASE ABOVE THE BASE COAT PAINT FOR ANY OF 6 UNSATURATED KETONE COMPOUNDS WHICH HE HAD FOUND AS CAUSING MUSHROOM ODOURS, IN THE JOURNAL OF AGRICULTURAL FOOD CHEMISTRY 1982, 30, 89-93 BY R. TRESSL ET AL., TITLED, "FORMATION OF EIGHT-CARBON AND TEN-CARBON COMPONENTS IN MUSHROOMS (AGARICUS CAMPESTRIS)". EVEN THOUGH IT WAS THOUGHT UNLIKELY THAT THESE UNSATURATED KETONES COULD BE IN THE PAINT FORMULATION, THE SOLVENT MANUFACTURER AGREED TO TEST THE PAINT FOR THESE COMPONENTS.

WITHIN A WEEK, TWO OF THE COMPOUNDS IDENTIFIED IN THE MUSHROOM PAPER HAD BEEN ISOLATED. BY VACUUM STRIPPING THE VOLATILES IN THE PAINT AND ANALYZING BY GC/MS THE COMPOUNDS 1-OCTENE-3-ONE AND 3-OCTENE-2-ONE WERE FOUND TO MAKE UP OVER 1.5% OF THE VOLATILE FRACTION.

THE MUSHROOM ODOURS WERE FINALLY LINKED TO THE VERY LOW LEVELS OF 1-OCTENE-3-ONE. THE SOLVENT SUPPLIER SYNTHESIZED A SAMPLE OF THE COMPOUND TO MAKE ODOUR THRESHOLD DETERMINATIONS, BUT IT WAS SO POTENT THAT NOT ONLY THE OLFACTOMETER EQUIPMENT BECAME CONTAMINATED, BUT ALSO THE ENTIRE LABORATORY SMELLED MAKING THE DETERMINATIONS IMPOSSIBLE. HOWEVER, A LITERATURE SEARCH INDICATED THAT THIS UNSATURATED KETONE WAS AS POTENT AS HYDROGEN SULPHIDE AND METHYL MERCAPTAN.

ADVISED OF THIS DISCOVERY, THE PAINT SUPPLIER SUGGESTED A CHEMICAL MECHANISM WHICH FORM THE 1-OCTENE-3-ONE. THE NECESSARY INGREDIENTS MAK, FREE FORMALDEHYDE AND AN ACID CATALYST WERE ALL PRESENT IN THE NEW HIGH SOLIDS BASE COAT PAINTS. THE ALDOL CONDENSATION OF MAK WITH FORMALDEHYDE (IN THE MELAMINE RESIN) OCCURRED OVER A PERIOD OF TIME TO PRODUCE AN UNSATURATED KETONE. **(FIG. #1)** THIS IS WHY A 95% REMOVAL OF MAK DID NOT IMPROVE THE SITUATION. THE REMAINING 5% WAS SUFFICIENT TO LET THE REACTION OCCUR. ONCE THE REMAINING MAK WAS TOTALLY ELIMINATED FROM THE PAINT FORMULATION, THE RESULTS WERE ASTONISHING. THE "MUSHROOM" ODOUR THAT WAS PREVIOUSLY DETECTABLE UP TO FOUR MILES AWAY HAD COMPLETELY DISAPPEARED.

WITHIN 6 MONTHS, MAK HAD COMPLETELY BEEN ELIMINATED FROM ALL OF OUR AUTOMOTIVE ASSEMBLY PLANTS IN NORTH AMERICA USING HIGH SOLIDS PAINTS. THE RESULTS WERE JUST AS IMPRESSIVE AT THE OTHER LOCATIONS WHICH HAD BEEN EXPERIENCING THE SAME TYPE OF ODOUR PROBLEMS. COMPLAINT LEVELS DROPPED DRAMATICALLY AND GOVERNMENT AGENCIES RELENTED ON CALLS FOR FURTHER ABATEMENT.

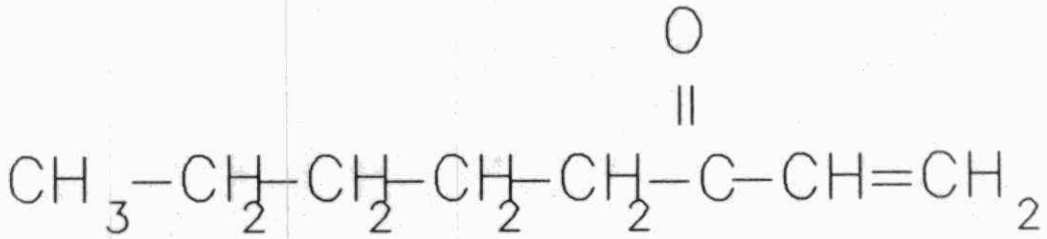
TO AVOID ODOUR PROBLEMS IN THE FUTURE, CHRYSLER IS NOW DEVELOPING NEW STANDARDS FOR ODOUR LEVELS IN NEW PAINTS BEING INTRODUCED INTO OUR ASSEMBLY PLANTS. NEW PAINTS ARE TESTED AS SPRAYED, USING THE TRIANGLE OLFACTOMETER WITH AN ODOUR PANEL. THE GOAL IS TO REDUCE THE OVERALL LEVEL OF THE ODOUR AND ALSO TO PREVENT A REOCCURRENCE OF THE "MUSHROOM-LIKE" REACTION PRODUCTS.

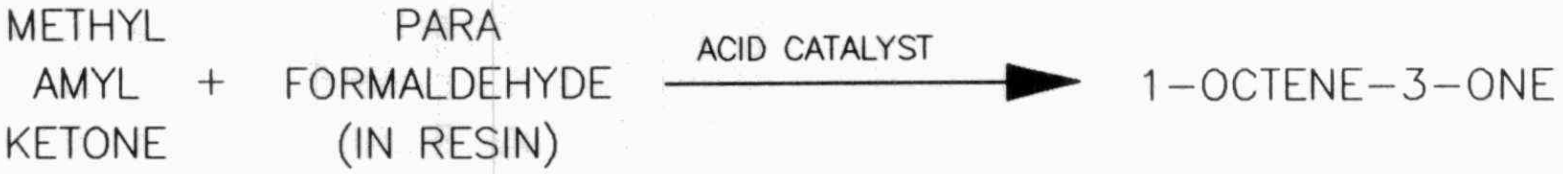
THIS PROGRAM OF REFORMULATION FOR ODOUR CONTROL IS THE MOST ECONOMICAL OF ALL THE METHODS AND SHOULD ALWAYS BE CONSIDERED BEFORE OTHER TYPES OF CONTROLS.

FIG. #1

FORMATION OF 1-OCTENE-3-ONE

(MUSHROOM SMELL)





ALDOL CONDENSATION

PH7

AMBIENT ODOUR TESTING

ALTHOUGH THIS WAS A SUCCESSFUL CONCLUSION TO THE ODOUR PROBLEM AT MANY ASSEMBLY PLANTS, THE WINDSOR FACILITY HAD OVER 300 HOMES WITHIN 1,500 FEET OF THE SOURCE AND ENOUGH COMPLAINTS WERE STILL RECEIVED FROM NEAR BY RESIDENTS WHO HAD BECOME SENSITIZED TO WARRANT FURTHER INVESTIGATION.

ERT CONSULTANT OF CONCORD, MASSACHUSETTS WERE RETAINED BY THE PAINT SUPPLIER, PPG, TO TAKE SAMPLES OF THE AMBIENT AIR AROUND THE PLANT. THE DATA OBTAINED FROM ADSORBING THE AMBIENT SOLVENT COMPONENTS ONTO TENEX TUBES SHOWS HOW COMPLEX ODOUR INVESTIGATIONS CAN BE. THE FIRST COLUMN SHOWS THE MAXIMUM AMBIENT CONCENTRATION FOUND AMONG ALL THE TUBES AND THE OTHER COLUMN SHOWS THE DATA COLLECTED FOR THE MINIMUM ODOUR THRESHOLD IN PARTS PER BILLION. INITIAL RESPONSE IS THAT NO ODOUR WOULD BE APPARENT BECAUSE ALL COMPONENTS ARE BELOW THEIR ODOUR DETECTION LIMIT, BUT SOMEHOW THROUGH CHEMICAL MIXING AND SYNERGISTIC EFFECTS, ODOURS DID EXIST WHICH COULD NOT BE QUANTIFIED BY CHEMICAL ANALYSIS ALONE.

IN THIS STUDY THE SAMPLES WERE COLLECTED OVER A PERIOD OF ONE HALF HOUR OR MORE IN ORDER TO OBTAIN ENOUGH SAMPLE FOR ANALYSIS; HOWEVER, IT WAS THOUGHT THAT PERHAPS MORE ACCURATE DATA WOULD BE OBTAINED IF INSTANTANEOUS CHEMICAL ANALYSIS OF THE AIR TOOK PLACE THE SAME TIME AS ODOUR STRENGTH MEASUREMENTS WERE TAKEN. THIS CONCEPT LED TO THE RETAINING OF TRC CONSULTANT OF HARTFORD, CONNECTICUT, IN THE FALL OF 1985. THEY WERE ASKED TO IDENTIFY AND QUANTIFY THE CHEMICAL COMPOUNDS IN THE AMBIENT AIR SURROUNDING THE PLANT WITH THE TAGA 6000 AND TO RELATE THE CONCENTRATION OF THESE COMPONENTS TO THE ODOUR STRENGTH DETECTED. THEY WERE ALSO ASKED TO DETERMINE THE

SOURCE OF ODOROUS COMPOUNDS AND TO ASCERTAIN THE NECESSARY REDUCTION IN ODOUR EMISSION RATES REQUIRED TO ELIMINATE THE COMPLAINTS IN THE NEIGHBOURHOOD. THE TAGA 6000 IS A VERY HIGH-TECH VAN EQUIPPED WITH DUAL MASS SPECTROMETERS WHICH ALLOWS FOR REAL TIME MONITORING AND IMMEDIATE IDENTIFICATION OF THE COMPONENTS IN THE AIR TO 2 PARTS PER BILLION. THE FIRST MS GIVES THE TRADITIONAL ANALYSIS OF MOLECULAR WEIGHTS JUST LIKE THE TAGA 3000 AND THE SECOND MS ANALYZES EACH MOLECULAR WEIGHT AND ITS DAUGHTERS. TOGETHER WITH THE ON-BOARD COMPUTERIZED LIBRARY AN INSTANT IDENTIFICATION OF THE COMPOUNDS IN THE AMBIENT AIR IS POSSIBLE. WHILE THE TAGA 6000 WAS PROVIDING THE CHEMICAL CONSTITUENTS IN THE AIR, AN OBSERVER USING A SCENTOMETER WAS NOTING THE CORRESPONDING ODOUR LEVELS. BY THIS METHOD TWO ADDITIONAL SOLVENTS WERE TARGETED FOR REFORMULATION AND TO DATE ONE HAS BEEN ELIMINATED AND THE OTHER MINIMIZED.

BY USING THE SCENTOMETER FOR DOWN WIND MEASUREMENTS, AN ISOPLETH MAP OF COMMUNITY ODOUR IMPACTS COULD BE ESTABLISHED AND BY CORRELATION WITH TRC'S ODOUR IMPACT MODEL, THE RESULTS WERE COMPUTERIZED TO GIVE US A DETAILED LOOK AT COMMUNITY ODOUR IMPACTS AT WORST CASE METEOROLOGY. A PERSON CAN DETECT AN ODOUR AT ONE THRESHOLD LEVEL; HOWEVER, BECAUSE OF VARIABLE WINDS AND GIVEN THAT ODOUR OCCURS IN PUFFS, 4 ODOUR UNITS OR FOUR TIMES ABOVE THE THRESHOLD WAS SELECTED AS THE AREA THAT THE ODOUR IS DETECTABLE BUT NOT ANNOYING ENOUGH TO BE UNPLEASANT.

THE SEVEN ODOUR UNITS' LEVEL WAS DETERMINED BY CORRELATION WITH EXPERIENCE AND ACTUAL COMPLAINT HISTORY THAT ANY AREA AT THIS LEVEL AND ABOVE WOULD GENERATE COMPLAINTS TO COMPANY OFFICIALS, GOVERNMENTAL AGENCIES AND POLITICIANS.

BY APPLYING TRC'S PROPRIETARY ODOUR IMPACT MODEL TO TWENTY DIFFERENT SCENARIOS OF ELEVATING STACKS AND ABATING THE ODOUR SOURCES, IT WAS POSSIBLE TO ARRIVE AT THE OPTIMUM ABATEMENT MODEL REQUIRED TO SATISFY THE COMMUNITY. THIS IS SHOWN FOR THE CASE OF ELEVATING ALL SPRAY BOOTH EXHAUST STACKS TO 65' ABOVE THE ROOF AND ABATING THE SOURCE OF ODOURS BY 50%. AS CAN BE SEEN, THE ODOUR IMPACT AREA OVER 7 UNITS WOULD BE REDUCED BY OVER 98%.

TO DETERMINE WHERE THE ODOUR WAS ORIGINATED IN THE 64 SPRAY BOOTH EXHAUSTS, TESTS OF THE TOTAL VOC'S WERE TAKEN FROM EACH INDIVIDUAL STACK AND ODOUR LEVELS FROM SELECTED ONES BY OUR OWN RESEARCH TEAM AND TRC'S. IN GENERAL THERE WAS GOOD AGREEMENT BETWEEN THE CONCENTRATION OF VOC'S AND THE ODOUR LEVEL. ALL STACKS EXHAUST NEARLY THE SAME FORMULATION OF RELEASED SOLVENTS SO, ALTHOUGH NOT AN EXACT SCIENCE, IT WAS ACCEPTED THAT ABATEMENT OF VOC'S WOULD RESULT IN A PROPORTIONAL DROP IN ODOUR. ALL STACKS WERE SUBSEQUENTLY RANKED IN ORDER OF DECREASING VOC EMISSIONS AND IT WAS DETERMINED THAT 16 OF THE 64 EXHAUST STACKS EMITTED 50% OF THE VOC'S FROM THE SPRAY BOOTHS.

IT WAS ALSO AGREED THAT THE VISIBLE VAPOUR PLUME APPEARING IN VERY COLD WEATHER WOULD APPROXIMATE THE PATTERN OF VOC AND ODOUR DISPERSION. AT THIS FACILITY THE STACKS ARE VERY LOW (18 FT.) IN RELATION TO THE HEIGHT OF THE BUILDING (86 FT.) AND THIS CAUSED THE ODOUR EMITTED TO BE CAUGHT IN THE TURBULENT WAKE CREATED BY THE BUILDING IN THE WIND. THE DOWN WASH WAS SO EFFECTIVE THAT THE ODOUR COULD BE DETECTED ONLY 20 FT. FROM THE BUILDING, EVEN THOUGH THE EMISSION SOURCE WAS OVER 100 FT. ABOVE THE GRADE.

WIND TUNNEL TESTS

ARMED WITH THIS INFORMATION, KINGS ENGINEERING, A CONSULTING ARM OF THE UNIVERSITY OF TORONTO'S MECHANICAL ENGINEERING DEPARTMENT WAS RETAINED TO PERFORM WIND TUNNEL TESTS ON A MODEL OF THE PAINT SHOP BUILDING TO ESTABLISH THE SMOKE PATTERNS FOR VARIOUS CONDITIONS AND STACK HEIGHTS. THE CONCENTRATION OF SMOKE IN THE MODEL NEIGHBOURHOOD WAS ESTABLISHED BY PHYSICALLY MEASURING THE DISPERSION OF THE PLUME AT SEVERAL WIND VELOCITIES. STACK HEIGHTS OF 18 FT., 45 FT., AND 65 FT. WERE EXAMINED FOR WORST CASE METEOROLOGY AT A WIND SPEED OF 10 MILES PER HOUR.

THE EFFECT ON THE COMMUNITY INDICATED A 50% DECREASE OF VOC'S WITH 65 FT. STACKS AT 500 FT. FROM THE SOURCE. SIMILARLY, AT DISTANCES FURTHER AWAY FROM THE STACKS, THE WIND TUNNEL TESTS INDICATED A MINIMUM OF 36% IMPROVEMENT. A SUBSEQUENT CHECK OF THE MODEL USING THE PROPOSED 308 REGULATIONS ALSO SHOWED A 30 TO 40% DECREASE IN GROUND LEVEL CONCENTRATIONS UNDER CONVECTIVE CONDITIONS.

RAISING STACKS

EVEN THOUGH REFORMULATION WAS ONGOING, ODOUR TESTS HAD INDICATED THAT SOME RESIDUAL ODOURS WOULD STILL BE PREVALENT AND THAT WE COULD NOT DEPEND ON IT ENTIRELY FOR ODOUR ABATEMENT FOR HOMES VERY CLOSE TO THE PLANT. ALL MODELS HAD INDICATED A SUBSTANTIAL DROP IN ODOUR BY RAISING THE STACKS TO 65 FT. ABOVE THE ROOF, SO THIS PROJECT WAS COMMENCED IN THE FALL OF 1986 FOR COMPLETION BEFORE THE START OF A NEW COMPLAINT SEASON IN MAY, 1987. AN AGREEABLE WINTER ALLOWED CONSTRUCTION TO PROCEED ON SCHEDULE AND BY MAY OF THIS YEAR ALL 64 STACK EXTENSIONS WERE IN PLACE.

THE STACKS WERE DESIGNED BY GILBERT/COMMONWEALTH OF JACKSON, MICH., AND INSTALLED BY A. G. BAIRD OF TORONTO.

THE CHANGES WERE IMMEDIATE, AND TO DATE THE STACKS HAVE PERFORMED BETTER THAN EXPECTED; THIS MAY BE IN PART DUE TO THE CONING EFFECT AND THE HIGHER VELOCITY DISCHARGE RESULTING. PRELIMINARY RESULTS FROM CLAYTON WHO SURVEYED THE AREA FOR SEVERAL WEEKS BEFORE AND AFTER THE STACKS WERE IN PLACE INDICATE AN 87% DROP IN INCIDENTS OF OVER 7 ODOUR UNITS IN THE AREA. DURING THIS SUMMER SHUTDOWN, ADDITIONAL PAINT FORMULATION CHANGES WILL OCCUR AND ALSO THE ADDITION OF ELECTROSTATIC BASE COAT SPRAY GUNS WILL RAISE THE TRANSFER EFFICIENCY AND LOWER THE AMOUNT OF EMISSIONS BY 15%. COMBINING THESE IMPROVEMENTS MAY BE SUFFICIENT TO AVOID COSTLY SPRAY BOOTH CONTROLS; HOWEVER, THE STACK SYSTEM HAS BEEN DESIGNED TO ACCEPT CONTROLS ON 16 TEES OFF THE HIGHEST EMITTING EXHAUST STACKS FOR A TOTAL OF 400,000 CFM AIR AT A FUTURE DATE.

VOC CONTROLS

SHOULD FURTHER CONTROLS BE REQUIRED FOR ODOUR CONTROL, THERE ARE TWO BASIC METHODS TO ABATE ODOURS. THE FIRST IS BY THERMAL INCINERATION AND THE SECOND BY CARBON ADSORPTION EITHER FIXED OR ROTARY FOLLOWED BY INCINERATION OR CONDENSATION TECHNIQUES.

THE ONLY ECONOMICAL TYPE OF DIRECT INCINERATION FOR SUCH HUGE VOLUMES IS THE REGENERATIVE TYPE. HERE THE GASES ARE CYCLED BACK AND FORTH ACROSS A STONEWARE BED WHICH ALLOWS UP TO 95% HEAT RECOVERY. REECO OF NEW JERSEY HAS 2-150,000 CFM UNITS OPERATING AT PPG CLEVELAND. THESE UNITS WERE INSTALLED FOR ODOUR CONTROL OF PAINT FUMES AND HAVE BEEN VERY SUCCESSFUL IN ABATING

ODOURS. A NEW 500,000 CFM UNIT IS CURRENTLY BEING INSTALLED IN TEXAS FOR AN AUTOMOTIVE PLANT TO ABATE VOC'S, AND ALTHOUGH ODOURS WERE NOT SPECIFICALLY TARGETED, THESE ALSO WILL BE DESTROYED.

ANOTHER TYPE OF PROVEN VOC CONTROL EQUIPMENT, IS THE ROTARY CARBON ADSORPTION SYSTEM FOLLOWED BY CATALYTIC INCINERATION. THIS IS A JAPANESE SYSTEM WHICH IS MANUFACTURED BY METPRO OF PENNSYLVANIA AND DURR INDUSTRIES IN NORTH AMERICA. IN THIS SYSTEM THE ROTARY CARBON WHEEL ADSORBS ODOURS AND VOC'S FROM THE SOLVENT LADEN AIR STREAM (SLA) ON 85% OF THE WHEEL AND DESORBS THE ORGANICS WITH HOT AIR ON THE LAST 15% PIE-SHAPED PIECE. THE CONCENTRATED STREAM IS THEN PASSED THROUGH A CATALYTIC INCINERATOR FOR ULTIMATE DESTRUCTION. A 25,000 CFM SYSTEM WAS INSTALLED LATE LAST YEAR ON A SPRAY BOOTH IN MICHIGAN AND THE RESULTS ARE VERY FAVOURABLE. FOR A 400,000 CFM SYSTEM, METPRO WOULD DESIGN 8-50,000 CFM MODULE UNITS.

THE THIRD TYPE OF VOC CONTROL EQUIPMENT IS THE FIXED BED CARBON ADSORBER. THIS SYSTEM IS TRIED AND PROVEN IN THE PRINTING INDUSTRY FOR SOLVENT RECOVERY, AND ALTHOUGH THERE ARE NONE CURRENTLY OPERATING IN AUTOMOTIVE PLANTS, ONE AUTOMOTIVE MANUFACTURER IS NOW INSTALLING A 500,000 CFM SYSTEM BY FLAKT IN GEORGIA FOR VOC CONTROL. TWO OTHER FIXED BED CARBON SYSTEMS ENGINEERED BY VARA OF FLORIDA WERE SCHEDULED FOR CONSTRUCTION AT AN AUTOMAKER, BUT LATER CANCELLED IN FAVOUR OF CONVERSION TO HIGH SOLIDS PAINT.

THE SYSTEM IS COMPRISED OF MULTIPLE ADSORBERS, DEPENDING ON THE SIZE REQUIRED. EACH ADSORBER WOULD HANDLE 50,000 CFM OF SLA AND AFTER BEING FULLY ADSORBED, STEAM WOULD BE EMLOYED TO DESORB THE CARBON. THE CONDENSED STEAM AND ORGANIC FRACTION COULD THEN EITHER BE RECOVERED AND SEPARATED, OR DESTROYED IN A LIQUID INCINERATOR.

ALL THREE TYPES PROVIDE EXCELLENT CONTROL OF ODOUR AND VOC'S AND THE FINAL CHOICE OF TECHNOLOGY WOULD DEPEND ON THE OWNER'S PREFERENCE.

SPRAY BOOTH MANUFACTURERS ARE NOW INSTALLING AND RETROFITTING BOOTHS WHICH RECIRCULATE A PERCENTAGE OF THE AIR, AND ALTHOUGH VOC CONTROLS ARE STILL REQUIRED, THE FINAL SIZE OF THE EQUIPMENT MAY BE CONSIDERABLY SMALLER AND MORE ECONOMICAL TO OPERATE.

CONCLUSION

THE RATE OF INTRODUCTION OF THE ABATEMENT EQUIPMENT INTHE AUTOMOTIVE INDUSTRY WILL BE LARGELY DEPENDENT ON THE U.S. EPA'S REQUIREMENTS FOR VOC CONTROL. AT THIS TIME SPRAY BOOTH CONTROLS SEEM VERY PROBABLE FOR THE FUTURE, ALTHOUGH CHANGES IN TECHNOLOGY TO WATER-BASED OR POWDER PAINTS MAY PRECLUDE THE NECESSITY FOR ADD-ON CONTROLS.

UNTIL THAT DATE, ODOURS WILL STILL BE WITH US AND WE IN THE AUTOMOTIVE SECTOR MUST RECOGNIZE THAT ODOUR MANAGEMENT AND CONTROL MUST BE AN INTEGRAL PART OF OUR OVERALL PROGRAM FOR EXCELLENCE.

ONTARIO HYDRO'S FLUE GAS DESULPHURIZATION PROGRAM

by

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- A STATUS REPORT -

Ontario Hydro is committed to achieving major reductions in its acid gas emissions in a cost-effective and environmentally acceptable fashion. In order to maintain the flexibility to meet future demands for electricity and comply with tightening acid gas regulations, it is likely that Ontario Hydro will have to retrofit some form of flue gas desulphurization (FGD) equipment on its existing coal-fired plants by the mid to late 1990's.

This paper discusses the studies being conducted by Ontario Hydro to select technologies and obtain government approval for the installation of appropriate FGD equipment at selected coal-fired stations. In order to satisfy requirements of the Ontario Environmental Assessment Act, a Program Environmental Assessment is being prepared that will request approval for the planning, design, construction, operation/maintenance and decommissioning of all FGD and associated facilities required over a 20-year planning period. Initial approval will be requested to retrofit specified FGD equipment on up to 20 coal-fired units at either Nanticoke, Lambton or Lakeview GS's.

Concurrent with the development of the Program EA, Ontario Hydro is carrying out FGD process evaluation and selection studies designed to identify the most appropriate technologies for use at its coal-fired stations. These studies consist of conceptual engineering as well as various research and development activities. Current studies are focussing on four candidate FGD technologies, including: wet limestone slurry, limestone dual alkali, lime spray dryer and furnace limestone injection. These processes will likely be considered for initial FGD units starting in 1994. However, process evaluation studies will be carried out on a continuing basis and any new processes or process innovations, which are more cost-effective and environmentally preferable, will be incorporated into the Program.

A major consideration in selecting and operating FGD equipment is waste management. Both the EA and process selection studies are dealing with waste management concerns to develop a cost-effective and environmentally acceptable approach. A number of waste management options and concerns are discussed.

1. ONTARIO HYDRO'S ACID GAS CONTROL PROGRAM

Ontario Hydro is under regulation to reduce its acid gas emissions by about 60 percent (of its 1982 emission levels) by 1994, and will be required to maintain this 1994 level regardless of future changes in demands for electricity. Future uncertainties related to load growth and the performance of existing generating stations suggest that compliance with this regulation will present a significant challenge for Ontario Hydro, particularly in the mid to late 1990's period.

While the regulation specifies a staged program of reduction limits for Ontario Hydro (Figure 1), it does not specify the methods to be used to meet these emission limits. It is left to Ontario Hydro to decide on the most appropriate way to meet the regulation. The extent of the difficulty Ontario Hydro will experience to satisfy the regulation in the early 1990's depends very much on a number of factors such as future load growth, the effectiveness of our conservation efforts, and the nature of future additions to the generation system, all of which are presently unknown. Consequently there is a very large element of uncertainty associated with any prediction of the need for acid gas emission control in the future. Ontario Hydro's approach to controlling emissions will be to maximize its flexibility by keeping a portfolio of options available that can be used in combination to minimize costs to the electricity consumer. As shown in Table 1, the options available to Ontario Hydro fall into three broad categories, including: reducing use of coal-fired generation, reducing the sulphur levels in fuels used at fossil plants and/or installing some form of emission control technology. Many of these measures are already being pursued while others, such as installing control technology, are being investigated as methods for the mid to late 1990's, when coal burns are expected to rise and emission limits under the current regulation bottom out.

Given the current forecast load growth of 2.6% per annum for the next 20 years, which incorporates a reasonable proportion of measures to both reduce coal use and/or reduce fuel sulphur levels, it is likely that it will be necessary for Ontario Hydro to retrofit flue gas desulphurization (FGD) equipment on selected existing coal-fired stations starting in 1994 (Ontario Hydro, 1987). As noted in Figure 2, this may require up to 8 FGD units to be installed prior to the year 2000. A higher load growth situation could significantly increase the number and rate of installation for FGD units during this time period.

2. FGD PROGRAM APPROVALS

Major changes to existing generating stations, such as retrofitting FGD equipment, require Ontario Government approval under the Environmental Assessment Act. Ontario Hydro has initiated a three-year, $7.7 million program to secure these approvals as well as carry out FGD process selection and specification work. The intent of this program is to have FGD approved and available as one of our options for the mid to late 1990's. This should improve Ontario Hydro's planning flexibility and allow its coal stations to be used effectively in this critical period.

In order to satisfy requirements under the EA Act, Ontario Hydro is preparing a Program Environmental Assessment (PEA) to be submitted to the Ontario Ministry of the Environment (MOE) in early 1988. EA Act approval is required by mid-1989 if a 1994 in-service date is to be met for the initial FGD units (Figure 3). Consultation with both the government and public is being carried out during the preparation of the PEA document.

The PEA document will describe a program of retrofitting FGD facilities at selected coal stations which may be required over a 20 year period (starting in 1994) to satisfy Ontario Hydro's requirements for controlling its acid gas emissions. Recognizing the uncertainties in load forecasts and associated acid gas emission levels, a very flexible program has to be proposed. Initially, approval is being sought to install FGD equipment, using one or more of four different FGD processes, on up to 20 units at either the Nanticoke, Lambton and/or Lakeview generating stations.

In particular, EA Act approval is being requested for the planning, design, construction, operation and maintenance, and retirement of FGD and associated facilities at these three stations. Major facilities associated with an FGD retrofit include:

(a) a reagent (limestone/lime) handling, processing and storage facility;

(b) waste handling and processing facilities including any new waste disposal sites;

(c) stack and ducting modifications or additions.

As shown in Figure 4, the PEA will assess the environmental implications of installing the four candidate technologies at any one of the three sites and will show the environmental acceptability of each process at each site. Approval of the PEA will give Ontario Hydro the choice to utilize any one of the options contained in the approved site versus technology matrix, as required, to meet its acid gas emission targets. Implementation of the various site and technology combinations will require that Ontario Hydro apply for specific permits and licenses under any other relevant environmental legislation (eg. Environmental Protection Act) necessary for facility construction and operation, and layout an implementation plan that incorporates pertinent mitigation and/or monitoring commitments.

An essential part of the flexibility built into the PEA will be a mechanism to routinely review and adjust the FGD Program to respond to changing system needs, FGD technological advancements and potential improvements to FGD process operating conditions (eg. a change in waste disposal site or option - such as marketing the waste for some useful purpose).

3. FGD PROCESS SELECTION STUDIES

In parallel with the Program EA, studies are also being carried out, on a site-specific basis, to select the most appropriate and cost-effective of four candidate FGD processes for installation at a specific generating station. Work has started on Lambton GS and will then proceed to Nanticoke and finally Lakeview, as depicted in Figure 3. Lambton was selected as the first site to study, because the highest sulphur coal is burned there and it is therefore likely to provide the most cost effective site for FGD. Nanticoke will be the next site studied and takes precedence over Lakeview because the annual capacity factors and acid gas emissions are typically much higher than Lakeview's. We anticipate having this second process selection study completed by the Fall of 1988. In order to have an FGD system installed and operating by early 1994 we must have a decision to proceed, including Environmental Assessment Act approval by September 1989 (Figure 3). Consequently, both the Lambton and Nanticoke process selection studies will have been completed by that time and either site could be selected for the initial units in 1994.

The processes that are currently being considered for initial application can essentially be divided into two categories, depicted in Table 2; these being high capital cost, high removal efficiency systems and low capital cost low removal efficiency systems. The wet limestone slurry processes, the lime spray dryer process and the limestone dual alkali process fit into this first category. The furnace limestone injection process fits into the second category. The Lambton study will concentrate initially on making a selection between the three high efficiency processes. This selection will be accomplished through the evaluation of process performance and cost data provided by suppliers of each process. An evaluation of the Furnace Limestone Injection process will commence in the fall of 1987, after completion of Phase III of the research and development work scheduled to take place in July and August at Lakeview GS. The Lambton site studies will provide our System Planning Division with capital cost, operating cost and performance information for the best high removal efficiency processes, as well as for the furnace limestone injection process. Under the present schedule for an in-service date of 1994, a choice between these two process efficiency options does not have to be made until the Nanticoke information is also available in September 1988.

A brief description of the FGD processes being considered and the technical issues which must be addressed follows.

Wet Limestone Slurry Process

The wet limestone slurry process Figure 5 is installed downstream of the existing electrostatic precipitators. Large quantities of slurry, typically of the order of 13 liters/m^3 (100 gal/1,000 ft^3) of gas are sprayed into the flue gas as it flows upwards through a spray tower absorber vessel. Sulphur dioxide is absorbed into the slurry where it reacts with dissolved limestone ($CaCO_3$) to produce calcium sulphite

($CaSO_3.1/2H_2O$) and calcium sulphate ($CaSO_4.2H_2O$), which precipitate from solution. A large recirculation tank provides about 10 minutes retention for the slurry before it is recirculated to the tower; this allows for precipitation of the reaction products onto seed crystals in the slurry and for recovery of the pH as more limestone dissolves. The slurry is typically 12-15% solids; mainly the reaction products. A mist eliminator at the outlet of the scrubber vessel removes entrained slurry droplets from the flue gas by impingement of the droplets on vanes. Slurry bled from the towers is dewatered for disposal of the waste solids.

The waste dewaters to only 50-60% solids and has the consistency of toothpaste. However, by blending this waste with fly ash and lime, a material with the characteristics of low strength concrete and a permeability of about 10^{-7} cm/sec is produced. This material is quite adequate for landfill disposal. In a variation of the process, air is bubbled through the recirculation tank to oxidize essentially all the calcium sulphite to calcium sulphate. This forced oxidation waste (gypsum) dewaters to 80%-90% solids and has good physical strength and the consistency and appearance of wet sand. It can therefore be landfilled directly. The anticipated physical and chemical characteristics for this material are presented in Tables 3 and 5 respectively.

A second approach to disposal of gypsum waste is the gypsum stacking method. Using this method (Figure 6), the gypsum slurry is directed to a dyked pond where gypsum settles out and the supernatent is returned to the scrubbing process. As the pond fills with gypsum, the settled material is excavated from the pond and used to elevate the dykes. Thus, over time, a stack of gypsum is created.

The limestone slurry process was studied extensively by Ontario Hydro in 1981. However some further evaluation is being carried out to address process developments since 1981. The following are some of the major issues related to the limestone slurry process.

(a) Operating Experience

Total utility operating experience with the limestone slurry process is now approximately two to three times greater than in 1981. Many "second generation" designs which had not started up in 1981 have now operated several years. This experience is being reviewed.

(b) Potential Suppliers

In the 1981 studies, four suppliers were considered to have successful experience on applications relevant to our application. It is necessary to evaluate the suppliers' experience since 1981.

(c) Materials of Construction

This is a critical aspect of the design of a wet system. Experience has increased several fold since 1981 and a significant number of surveys and evaluations have been published.

(d) Organic Acid Enhancement

The addition of small amounts of organic acids such as adipic acid or dibasic acid (DBA) to limestone slurry systems has been shown to enhance scrubber performance with advantages in terms of both capital and operating costs. However, it seems most utilities considering or specifying new systems have been reluctant to allow the designer to take advantage of these promoters in the design. Hydro will evaluate for itself whether or not to take advantage of this development.

(e) Water Balance

A major issue with respect to the wet limestone slurry process is the need to eliminate releases of process wastewater. Regulatory concern for releases of process wastewater has increased since 1981, although it is still arguable whether there are significant unacceptable environmental effects from the discharge of wet limestone slurry FGD waste water. The concern arises due to dissolved salts, principally calcium chloride, and small quantities of heavy metals contained in the wastewater. We expect wastewater releases from the limestone slurry process will be an issue in the environmental assessment. Ideally, the addition of water to the process would balance the water consumed due to evaporation into the flue gas and the water leaving the process with the waste, as either water of hydration or as interstitial water. Operating in such a mode would be considered "closed-loop"; all of the dissolved salts leave the system with the solid waste (Figure 7). However, most installations find that the fresh water requirements for limestone milling, pump seals and effective mist eliminator washing exceed the amount of water leaving with the flue gas and the waste, with the result that a process wastewater stream is produced. There is very little experience either designing or operating wet limestone slurry systems "closed-loop".

Any reduction in the effective blowdown rate of process water, whether as interstitial water in the waste or as a separate process wastewater stream, will result in higher equilibrium chloride levels in the process water. This has implications for materials of construction, SO_2 removal performance, and for waste disposal.

If closed loop operation becomes a requirement, selection of the preferred approach will require an overall optimization of:

(1) the SO_2 removal process (natural oxidation versus forced oxidation, two stage versus one stage)

(2) the waste disposal method

(3) materials of construction

(4) measures to minimize fresh water requirements for mist eliminator washing and pump seals

(5) wastewater treatment, including evaporation

This is an area which has not been understood or adequately addressed during the specification and design of many existing systems, with the result that many systems which were expected to operate "closed-loop", cannot do so.

Limestone Dual Alkali Process

The dual alkali process Figure 8 is a wet scrubbing process which would be installed downstream of the existing electrostatic precipitators. The flue gas is scrubbed with clear solution rather than a slurry. SO_2 is absorbed into the sodium sulphite solution and reacts to produce sodium bisulphite. The absorbers operate at relatively high pH and relatively low liquid to gas ratios compared with the limestone slurry process. Very high SO_2 removal efficiency (over 95%) is easily achieved. Because a clear solution is used for scrubbing, problems with plugging, erosion, and mist eliminator fouling are essentially eliminated. The process is easier to operate as a closed water balance, because mist eliminator fouling is not a problem and pump seal water requirements are much lower, due to the reduced liquid to gas ratio. Process control is more forgiving than for the wet limestone slurry process. Corrosion conditions in the absorber are somewhat less severe due to the high pH. The absorbers are smaller.

Outside the absorber a bleed system of scrubbing solution is regenerated by the addition of limestone. The regeneration may be located separate from the absorbers. The sodium bisulphite reacts with the calcium carbonate to produce sodium sulphite and calcium sulphite which precipitates from the solution. The calcium sulphite waste is dewatered using thickeners and vacuum filters and the filter cake is washed to minimize sodium losses in the cake. Unlike the calcium sulphite waste produced from the limestone slurry system without forced oxidation, the waste from the dual alkali process dewaters to approximately 70% solids and direct landfill is used at some installations. At other installations the dewatered waste is blended with dry fly ash and lime (as for wet limestone slurry systems) to improve its strength and reduce permeability, and is then landfilled. Typical waste characteristics are presented in Tables 3 and 5.

The dual alkali process has been applied commercially since 1979 at a total of six utility installations using lime rather than limestone for regeneration (PEI Associates, 1985). These installations have demonstrated high reliability, however, the high cost of lime is a disadvantage. Therefore, development work has been directed towards the use of less expensive limestone to regenerate the scrubbing solution.

The limestone-regenerated process has been successfully tested by FMC Corporation at a 3 MW pilot facility for over one year and also since August 1984 by Central Illinois Public Service Company at a 585 MW system originally designed as a lime dual alkali process. FMC offers the process commercially.

Although there has been relatively little operating experience with the limestone-regenerated version of the dual alkali process, the potential advantages of the process demand that it be thoroughly evaluated as an alternative to the limestone slurry and lime spray dryer process.

Following are some of the major technical issues which are being evaluated with respect to the limestone dual alkali process.

(a) Reagent Selection

Has the limestone regeneration been demonstrated sufficiently to commit a commercial installation? As already noted, there is limited experience with the limestone-regenerated process.

What are the effects of limestone properties on the process? Are local limestones suitable? Some reports indicate the performance or at least the design of the process is sensitive to the properties of the limestone and particularly the magnesium content.

(b) Waste Management

Does the waste require fixation? What are the costs of environmentally acceptable waste disposal methods? The waste will contain approximately 2-5 moles of highly soluble sodium per 100 moles of SO_2 removed. Is fixation required to control leaching from the waste or for physical stability?

(c) Water Balance

What is the value, if any, of closed-loop operation? Is closed-loop operation an environmental requirement? Assuming closed-loop operation is easily achieved with the dual alkali process but expensive on a limestone slurry process, this could be evaluated as a cost to the limestone slurry process.

(d) Materials of Construction

Materials of construction in the absorber. The higher pH and reduced erosion in the absorber may suggest different construction materials than for the limestone slurry process.

(e) Costs

What credits, if any, should be allowed for operating labour costs and maintenance costs relative to the limestone slurry process? Maintenance costs should be lower.

What credit, if any, should be allowed for operating reliability, relative to the limestone slurry process? Clear solution scrubbing should improve reliability.

What credit, if any, should be allowed for higher SO_2 removal efficiency? The value will depend on the possibility of higher than forecast coal burns and the cost of incremental control.

Ultimately, having considered the above issues, what are the capital and operating costs relative to the alternatives, for Ontario Hydro application(s).

Lime Spray Dryer Process

In the lime spray dryer process (Figure 9) a concentrated slurry of slaked lime is finely atomized into the flue gas in an absorber vessel located downstream of the air heaters. A high speed rotary atomizer is used by most suppliers. SO_2 is absorbed into the slurry droplets, which are simultaneously being evaporated by the hot flue gas. Whereas a wet scrubbing process completely saturates the flue gas, in the lime spray dryer process the water addition is controlled to ensure that the flue gas is cooled only to approximately 20°F above its saturation temperature. The duct walls remain dry and the reaction products are also dry. The dried slurry solids are collected with the fly ash in an electrostatic precipitator or fabric filter.

With the lime spray dryer process the corrosion problems associated with wet scrubbing processes are essentially eliminated. Carbon steel construction is used for the absorbers, ductwork and precipitators or fabric filter. Erosion problems due to handling are significantly reduced; the quantity of slurry sprayed into the flue gas in a lime spray dryer application is less than 1% of that used in a wet limestone slurry process. There is no liquid effluent problem. Operating labour and maintenance costs should be lower than for a wet scrubber. Since the flue gas is not saturated, a new low velocity wet stack is not required. The high cost of lime is a disadvantage, but preliminary studies indicate this may be offset by reduced operating labour and maintenance costs.

The waste from the Lime Spray Dryer process is dry. Typical waste characteristics are shown in Tables 3 and 5. This material would be suitable for direct landfill. It contains large amounts of fly ash, but because of the residual calcium hydroxide reagent, is more alkaline than the parent fly ash. In the dry state, the material has permeabilities typical of fine sand, but if water is added, the material will set up with characteristics of a low strength concrete and permeability of about 10^{-7} cm/sec. To avoid the handling problems associated with wetting this material, it would be our preference to landfill the dry waste.

The lime spray dryer process has been applied commercially on 13 utility applications in the US since 1980; five additional units have been sold (PEI Assoc., 1985). Reliability performance has generally been good. Most of the experience is on low sulphur coal and using fabric filters for particulate collection. There has been pilot scale, industrial scale

and limited short term utility scale testing on high sulphur coal. Ontario Hydro is participating in a 10 MW pilot scale development program at TVA to test the process for retrofit applications burning high sulphur coal and using electrostatic precipitators for particulate collection. The TVA pilot started up in late 1986.

Some of the major technical issues which must be evaluated with respect to the lime spray dry process are as follows:

(a) System Design

The design of a lime spray dryer system requires an overall optimization of the combined spray dryer and particulate collection system. Lime utilization is particularly critical on a high efficiency high sulphur coal application, compared to low efficiency, low sulphur applications.

(b) Approach Temperature

A lower absorber outlet temperature (i.e., a closer approach to the saturation temperature) improves lime utilization but presents a greater risk of plugging the absorber and particulate collection equipment with wet solids. Higher inlet temperatures can improve lime utilization but at the expense of boiler efficiency.

(c) Recycle

Increased recycle of waste solids to the absorber improves lime utilization but requires operation at high slurry solids and increases the dust loading to the precipitator. A fabric filter improves lime utilization but involves higher capital costs than a precipitator. This optimization is complicated by the fact that our existing units are fitted with electrostatic precipitators, which introduces layout difficulties.

Furnace Limestone Injection

Conceptually, the furnace limestone injection process involves the injection of alkali material (limestone or hydrated lime) into the furnace cavity at an optimum temperature of close to 1000°C (Figure 10). The injection temperature is critical to the process in that it must be high enough to calcine the limestone but low enough to avoid deactivation of the limestone by sintering. Also, the sulphation reaction occurs in a very narrow temperature window which lies between the optimum injection temperature of 1000°C and about 800°C. Since the flue gas is typically resident in this temperature window less than one second, it is obviously extremely important to be able to distribute the alkali material into the flue gas very rapidly. To provide the large surface area necessary for the sulphation reaction to occur in the short space of time available the limestone is ground to a size of about 70% - 200 mesh, the same size as

that used in the limestone slurry process. Thus the reagent handling and preparation aspects of the process would be very similar to those for the limestone slurry process.

Test work at Lakeview has so far concentrated on a tangentially fired boiler burning 1.7% sulphur coal. On this unit we have been able to achieve on SO_2 removal efficiency of 43% when injecting limestone at a stoichiometry of 4:1. With lime injection, a removal efficiency of 49% has been achieved at a stoichiometry of 2.8:1. This year, work will concentrate on establishing what can be achieved with a front wall fired unit under similar conditions.

The single largest problem to be faced with this process, at present, is the poor performance of the existing electrostatic precipitator which is being asked to cope with three to four times the amount of particulate for which it was designed. We are only able to test the process for about 3 hours before deterioration of precipitator performance forces curtailment of the test. The problem could be resolved, of course, by the addition of more precipitator capacity or a fabric filter, but this would add significantly to the capital cost and seriously undermine the capital cost advantage that this process offers. One of the objectives of this years test program will be to evaluate the potential of flue gas conditioning by SO_3 addition, to reduce the resistivity of the particulate and thus restore precipitator performance.

Pilot scale work, carried out by our Research Division at the Combustion Research Facility, has indicated that quite substantial incremental improvements in SO_2 capture of up to 20 percentage points can be achieved by humidification of the flue gas after the air preheater. This humidification process also offers the dual benefits of reduced flue gas volume, due to cooling, and reduced particle resistivity, both of which should contribute to improved precipitator performance. These process developments could be explored at a larger scale in a 1988 test program.

The waste from the Furnace Limestone Injection Process is similar to Lime Spray Dryer waste in that it is collected in a dry state. However, it contains much more unreacted material than Lime Spray Dryer waste due to the higher reagent to SO_2 stoichiometry used in the process. Furthermore, most of this unreacted material is in the unslaked, calcium oxide form. Typical waste characteristics are presented in Tables 3 and 5. Percolation of water into large volumes of this material in a landfill would result in the generation of quite high temperatures of about 160°C which would result in steam generation as well as heaving and fissuring of the landfill. Clearly then, this material would have to be slaked in a controlled manner at the station before it was landfilled. Once slaked, the addition of more water results in a plaster like material that appears to be quite adequate for landfill disposal.

The major outstanding issues that remain to be resolved with this process are:

(a) Humidification

Confirmation at full-scale of the ability of flue gas humidification to improve SO_2 capture and precipitator performance;

(b) Reagent Selection

The economics of achieving improved SO_2 capture through the use of calcium oxide rather than limestone;

(c) Waste Management

Demonstration, at a significant scale, of a process to slake the waste material to produce acceptable landfill material;

(d) Additives

Determination of the benefits that may be achievable in terms of SO_2 capture and precipitator performance through the addition of small amounts of additives such as sodium hydroxide to the reagents;

(e) Method of Injection

The benefits of a limestone slurry injection system into the furnace.

4. WASTE MANAGEMENT CONSIDERATIONS

As noted in the previous section, all the candidate FGD processes currently being considered by Ontario Hydro are "throwaway" systems, and have the capability to produce significant quantities of waste materials. Typical, waste quantities from scrubbed coal-fired units will be about three times the volumes produced using conventional unscrubbed units. The various types and characteristics of waste that can result are described above. The final quantities produced will be very sensitive to assumptions concerning station capacity factors, the FGD process used and coal quality.

Effective waste management will be a key component of installing and operating FGD systems at any of the three Ontario Hydro sites. A variety of options exist for effectively managing wastes produced by throwaway processes. The suitability of each option will be governed to a large degree by the specific FGD process selected (Figure 11). The selection of the most appropriate waste management scheme will be dependent on a

number of factors, including: waste quality and quantity, land availability and suitability, integration and existing ash handling systems, economics and long-term plans for waste recovery, utilization or site rehabilitation.

Generally, FGD wastes are managed using either wet (stacking) or dry (landfilling) disposal techniques. Limestone slurry and limestone dual alkali process wastes can be handled using a range of wet or dry techniques, while wastes from lime spray dryer or furnace limestone injection processes are generally dry landfilled with some water conditioning to minimize dust problems.

Potential environmental concerns associated with waste disposal include:

(a) displacement of land areas for landfill or stacking

(b) leaching or surface runoff with potential for contaminating nearby waterbodies

(c) aesthetic impacts (eg., dust problems, visibility of landfill or stack)

(d) traffic problems associated with transport of waste to an off-site disposal facility

(e) waste site rehabilitation

Some of these concerns are discussed briefly below in terms of the studies Ontario Hydro has undertaken to assess them, as well as potential options or mitigation that could be used to minimize adverse impacts.

Land Displacement

Table 4 summarizes potential land areas required to store FGD wastes from the three candidate generating stations. The quantities vary depending on the process selected, although land requirements are very similar for the three high efficiency processes. The furnace injection (LIF) process produces significantly more waste due to its high reagent to SO_2 stoichiometry, thereby retaining sizeable residual quantities of unreacted reagent. While these estimates represent very conservative requirements, they do indicate the magnitude of the waste disposal problem. Since there is little or no available on-site space remaining at any one of the three sites, it will be necessary to acquire additional off-site property for FGD waste disposal purposes. Ontario Hydro's current preference would be to acquire property contiguous to or as close as possible to its existing stations. This would reduce waste handling and transportation costs, provide maximum operating flexibility (eg. slurry pipeline option) and reduce transportation concerns in local communities. Preliminary geotechnical studies have established the suitability of contiguous properties at Nanticoke and Lambton for FGD waste disposal. While this option appears to be viable for both Nanticoke and Lambton, there is no available, adjacent property at

Lakeview GS. For the purposes of the PEA, Ontario Hydro is assuming that Lakeview wastes would be transported (probably by train) to a disposal site adjacent to Nanticoke. Concurrently, studies are underway, as part of rehabilitation investigations at Lakeview GS, to identify a more reasonable disposal option (eg., local pit or quarry).

While landfilling or stacking waste on adjacent sites appears to be a cost-effective and environmentally acceptable means of managing the wastes produced, Ontario Hydro is also assessing options to market or utilize these wastes for constructive purposes. By-product waste utilization could help to reduce Ontario Hydro's long-term needs for off-site storage space. Some of the areas being examined include: commercial gypsum production for wallboard, and using waste for pit or quarry rehabilitation, roadfill, mine backfill, stabilization of hazardous liquid wastes, or as a cement or soil additive (Ontario Hydro, 1984). The adoption of any one of these options will be dependent on a series of factors which are, at this point in time, difficult to predict. For example, it is uncertain what the demand for these materials may be in 1994 and beyond. Many of the options will be very sensitive to transportation costs and will require site-specific evaluations to determine their viability. Market penetration for "new" products like FGD gypsum will be complicated by the high degree of vertical integration that currently exists in the gypsum industry. It is unlikely also that any potential user is going to commit himself to taking this waste or by-product this far in advance. The flexibility built into the PEA should allow Ontario Hydro to take advantage of these opportunities should they arise some time in the future. For present planning and assessment purposes then, the adjacent disposal option appears to be a reasonable and conservative approach.

Leachate and Runoff Concerns

In disposing of FGD waste, leachate can result from water used for waste transport, process water occluded in the waste or as a result of precipitation permeating the waste material. The resultant outflow from the side and bottom surfaces of the landfilled or stacked material may contain soluble or collodial species which have been removed from the FGD waste. Leachate from the waste has the potential for entering and affecting local surface and ground water resources. The level of concern relating to leachate migration or surface runoff from FGD waste will be dependent on the FGD process selected and the waste disposal technique used to manage process wastes.

Waste composition will depend on a number of factors including: reagent type and purity, proportion of flyash, quality of water used for conditioning, and extent of oxidation. It is also time-dependent. Of particular interest with respect to potential environmental impacts is a waste's permeability and its trace element and total dissolved solids content.

The permeability of a waste can indicate its pollution potential. Generally, sludge-flyash blends stabilized with small percentages of lime exhibit permeabilities in the 10^{-7} to 10^{-8} cm/sec range. Synthetic gypsum solids, formed by the oxidation of FGD sludge, possess

permeability coefficients of about 10^{-4} cm/sec. Disposal of these solids in a wet gypsum stack presents probably the worst case from a leachate generation standpoint from among all the FGD waste management techniques currently being assessed by Ontario Hydro.

The construction and operation of a gypsum stack at Lambton and Nanticoke GS will alter the local ground water conditions. Leachate migration rates and fluxes would be larger than those predicted if natural ground water flow conditions were assumed. In cases where high permeability or thin overburden conditions exist, it may be necessary to place a clay or other impervious material prior to stacking or landfilling. Environment Canada has recommended that a liner one metre thick with a permeability of 5×10^{-7} cm/sec be used to separate wastes from waterbodies in the vicinity of any disposal site where site conditions will not restrict leachate migration to acceptable levels (CH_2M Hill et al, 1985). Preliminary geotechnical investigations at Nanticoke GS suggest that soil conditions at some locations are such that an impervious clay liner may have to be considered for any potential wet gypsum stacking (and possibly for landfilling) operation. At Lambton, the presence of a 45 metre thick clay deposit should minimize any potential for leachate migration from waste deposited on property adjacent to the existing generating station property.

The levels of trace elements in FGD waste and its resulting leachate quality are strongly influenced by the flyash content of the treated waste. Dry scrubber systems will therefore possess the highest trace element concentrations, since the waste resulting from these processes is essentially a mixture of scrubber solids, flyash and unused reagent. The level of flyash in wet based system is more easily controlled and will be a function of the degree of fixation or stabilization required. Analysis of leachate from existing FGD waste disposal facilities and from existing Ontario Hydro fly ash disposal sites indicate that the leachate will be alkaline and may have some trace element concentrations (e.g., arsenic, selenium, cadmium and boron) in excess of drinking water standards (Dodd et al, 1981, Heystee et al, 1984). Precise waste characteristics from any one FGD system cannot be established until a waste is produced and tested, however, preliminary leachate extraction tests performed on representative wastes from FGD processes and an assessment of data obtained from US facilities (Table 5) suggest these wastes can be considered non-hazardous with respect to standards specified in Regulation 309 under the Environmental Protection Act (Golomb, 1986a; Golomb, 1986b). The principle concern regarding FGD waste will be the high dissolved solids (TDS) levels, particularly sulphates and chlorides, in the waste site leachate. Leachate TDS from FGD scrubber sludge will typically range from 1000 ppm to 3000 ppm. High TDS values pose mainly an aesthetic problem for receiving waterbodies, not a potential health hazard. TDS levels can be controlled through proper landfill design and management, including runoff containment and/or treatment, if required.

Waste Site Rehabilitation

Any approval for FGD landfilling or wet stacking will require that Ontario Hydro make provisions for site rehabilitation once a disposal site is full or waste production is curtailed. Site rehabilitation can be practiced progressively throughout the life of the disposal facility or at the end of its useful life. The most appropriate approach will be a function of regulatory requirements, local concerns (e.g., dust) and site-specific conditions. Municipal and regional land use plans for designated waste sites will be particularly important in dictating rehabilitation planning. These types of decisions will not likely be made until detailed design work is initiated at a given site.

Proper rehabilitation should improve the long-term aesthetics of an area and have environmental benefits such as dust control and reduction in the potential for surface and ground water contamination in the post-closure phase. For example, the placement of a clay cap on the waste disposal mound and its grading to promote runoff should help to limit leachate generation.

Site rehabilitation should also provide the potential for site reuse. A properly rehabilitated FGD waste site should provide an opportunity for a variety of potential end uses ranging from agricultural to recreational to industrial or residential purposes. Revegetation of FGD waste may be possible but is complicated by problems of trace element (e.g., boron) toxicity, alkalinity, high sodium levels and or low moisture availability (Giordano, 1954). Many of these problems can be overcome by allowing adequate weathering time or amending waste with organic matter, fertilizer or soil. Applying a complete cover of soil over a capped landfill or stack may provide the best results in terms of potential for returning a site to agricultural purposes. Early establishment of a grass or legume cover will help to stabilize the surface by preventing erosion. Most forms of FGD waste materials appear to have sufficient compressive strength to support structures (EPRI, 1980). For fixated waste, for example, pozzolanic reactions between the lime and flyash in fixated sludge result in waste hardening and reduced permeability, making it quite acceptable as a structural base for buildings or roads.

5. SUMMARY

Ontario Hydro is committed to reducing its contribution to the acid rain problem and has achieved significant acid gas emission reductions over the past 5 years. Current efforts appear adequate until the mid-1990's, when forecasters suggest that, in order to maintain optimal flexibility, Ontario Hydro may need the option of installing some form of FGD technology on its large coal-fired units to comply with its emission limits for this period.

To ensure that the scrubber option is available in the critical mid to late 1990's period, studies are starting now to secure EA Act approval for a program of retrofitting FGD equipment at our Lambton, Lakeview and Nanticoke generating stations. At the same time, studies are progressing

to assess and select appropriate FGD technology(ies) for use at these stations. Four candidate technologies - wet limestone slurry, limestone dual alkali, lime spray dryer and furnace limestone injection - are under detailed review for initial application. Flexibility built into the EA Act approval will allow Ontario Hydro to insert new technologies as they become more practical in future.

Waste management will be a major concern when operating FGD systems. Waste volumes resulting from retrofitting FGD at selected facilities will increase by about three times those currently experienced using conventional, unscrubbed coal-fired units. Waste products are generally characterized as non-hazardous and can be managed using a variety of wet or dry techniques. The type of waste management system selected will be dictated to great extent by its parent FGD process. Environmental concerns for FGD waste management will be mainly related to land displacement required for landfilling or stacking purposes and potential leachate impacts on neighbouring waterbodies. Over 400 ha of off-site storage space may be needed to accommodate lifetime FGD wastes from these three stations. Results from leachate extraction tests combined with information regarding hydrogeological conditions at areas adjacent to the Lambton and Nanticoke sites suggest that FGD waste management should not be a significant concern given proper waste site design, preparation, operation and rehabilitation (including adequate provisions for monitoring). Over the long-term, it is Ontario Hydro's intent to actively pursue markets for these wastes. Any opportunities to make constructive use of these materials will reap benefits by reducing lifetime landfilling requirements at the three stations.

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FIGURE 1
ONTARIO HYDRO
ACID GAS EMISSIONS
(x 10^3 tonnes)

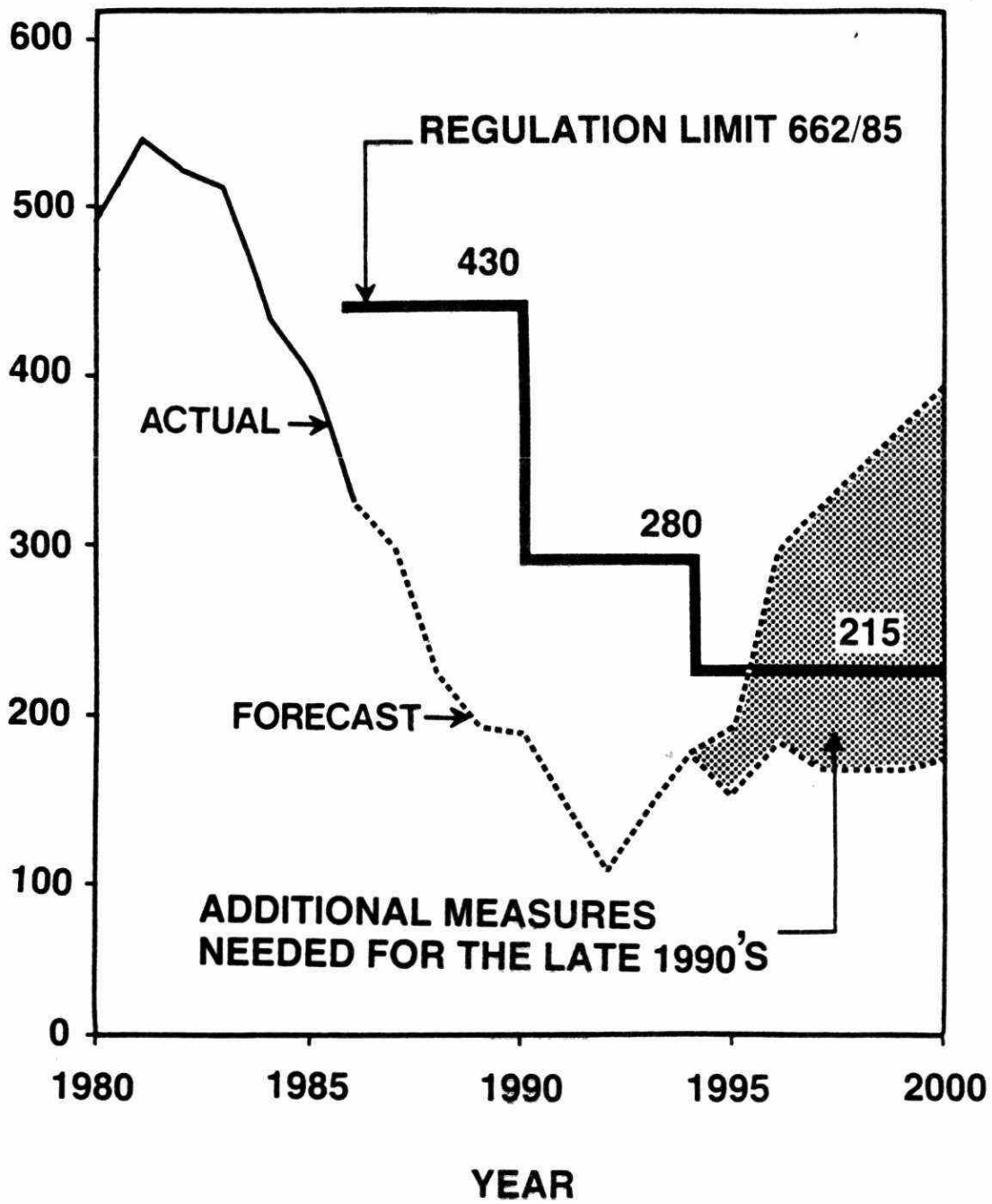
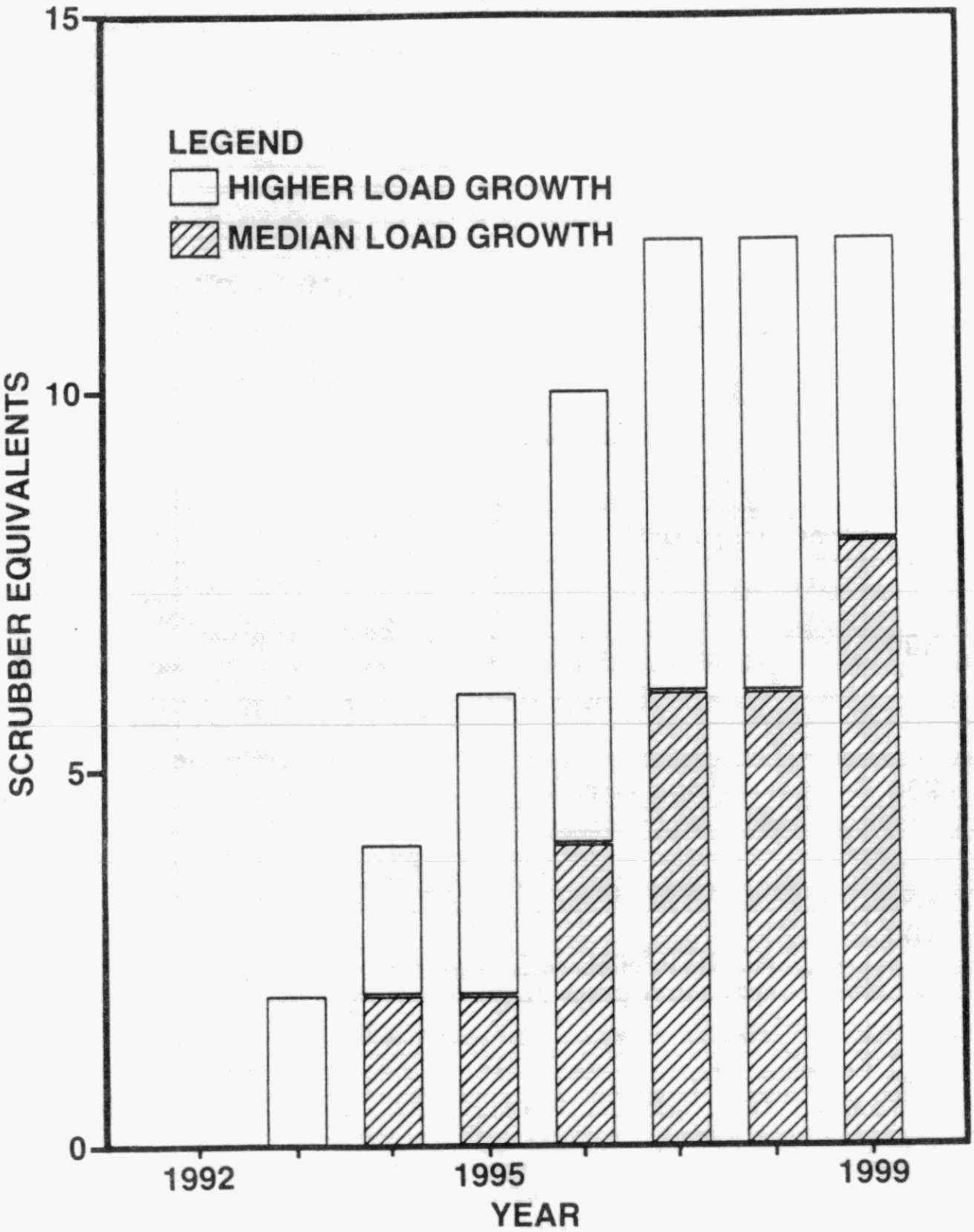


FIGURE 2
NEED FOR SCRUBBERS OR EQUIVALENTS



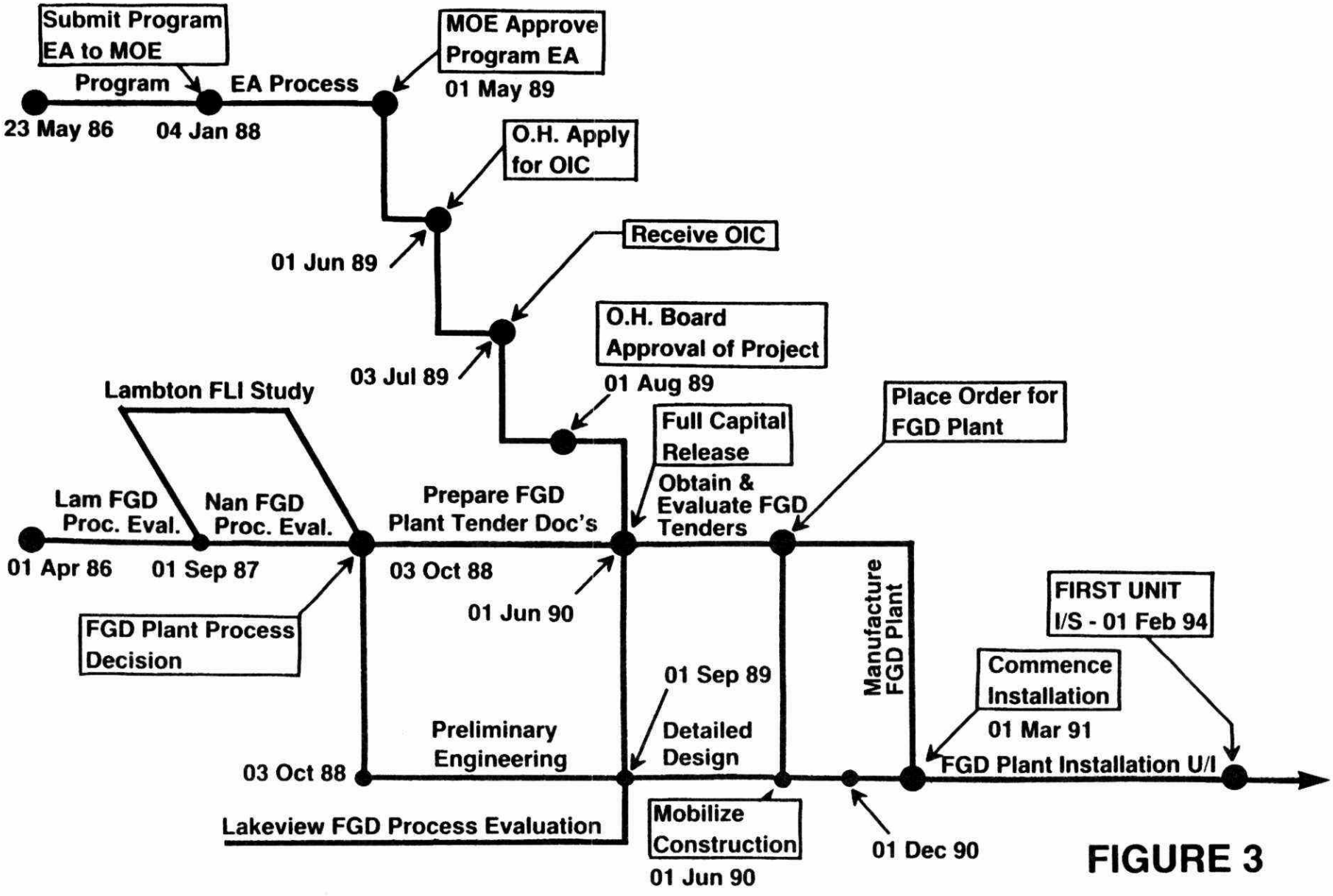

Submit Program EA to MOE
Program
EA Process
MOE Approve Program EA
01 May 89
23 May 86
04 Jan 88
O.H. Apply for OIC
01 Jun 89
Receive OIC
O.H. Board Approval of Project
03 Jul 89
01 Aug 89
Lambton FLI Study
Full Capital Release
Place Order for FGD Plant
Lam FGD Proc. Eval.
Nan FGD Proc. Eval.
Prepare FGD Plant Tender Doc's
Obtain & Evaluate FGD Tenders
01 Apr 86
01 Sep 87
03 Oct 88
01 Jun 90
FGD Plant Process Decision
Manufacture FGD Plant
FIRST UNIT I/S - 01 Feb 94
Commence Installation
01 Mar 91
01 Sep 89
Preliminary Engineering
Detailed Design
03 Oct 88
FGD Plant Installation U/I
Lakeview FGD Process Evaluation
Mobilize Construction
01 Jun 90
01 Dec 90

FIGURE 3

FIGURE 4

FGD PROGRAM - EA PLANNING AND IMPLEMENTATION PROCESS

PLANNING → IMPLEMENTATION (Design, Construction & Operation) ← AMENDMENT

SITE X TECHNOLOGY MATRIX

SITE \ TECHNOLOGY	WET LIMESTONE SLURRY	LIMESTONE DUAL ALKALI	LIME SPRAY DRYER	FURNACE LIMESTONE INJECTION
LAMBTON				
NANTICOKE				
LAKEVIEW				

SITE X TECHNOLOGY COMBINATION

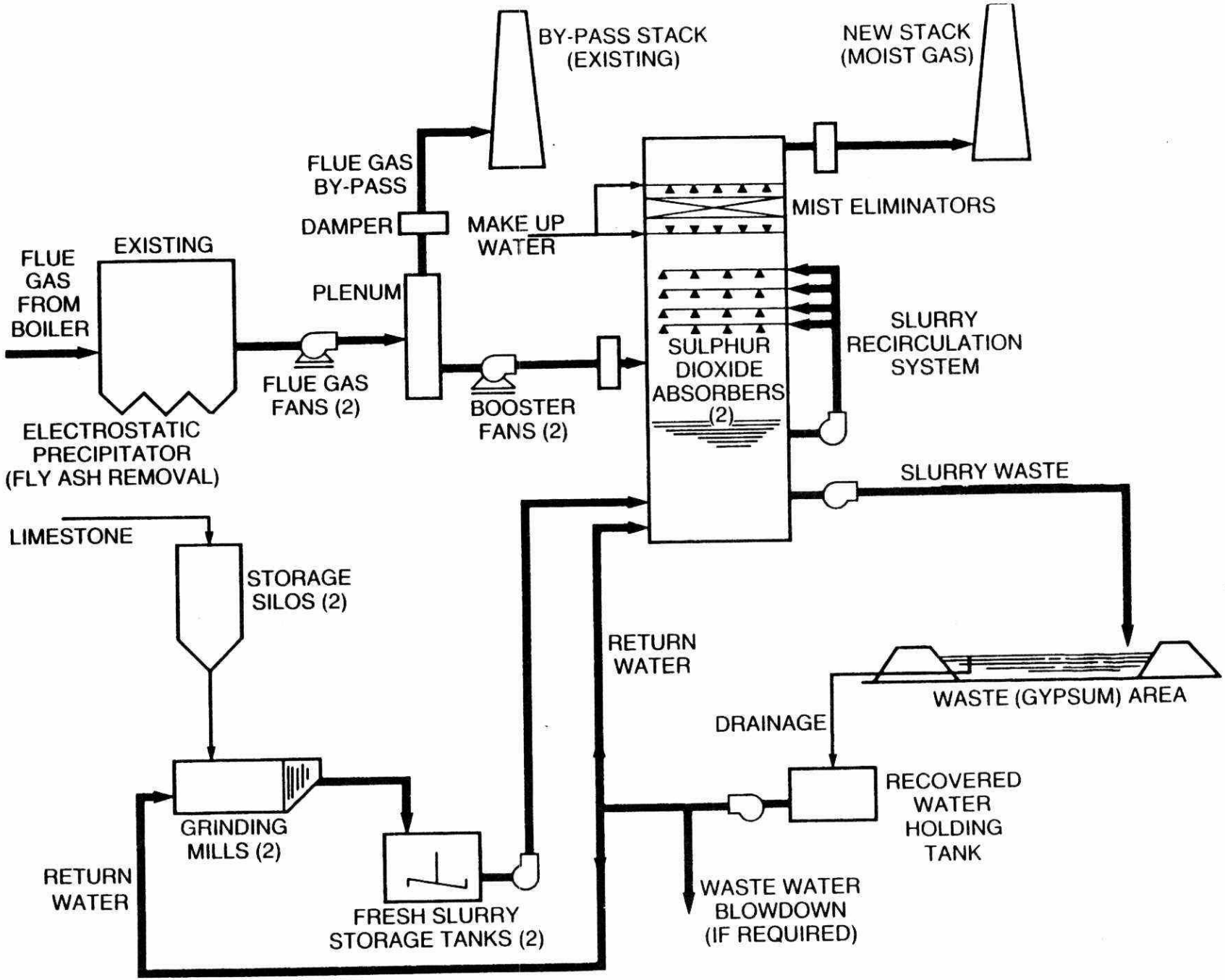
Selection Factors
- Load Growth
- System Needs/Constraints
- Process Selection Studies

- NEW SITE (S)
- NEW TECHNOLOGY (S)
- NEW WASTE DISPOSAL OPTION(S)

- PROGRAM EA (EA ACT)

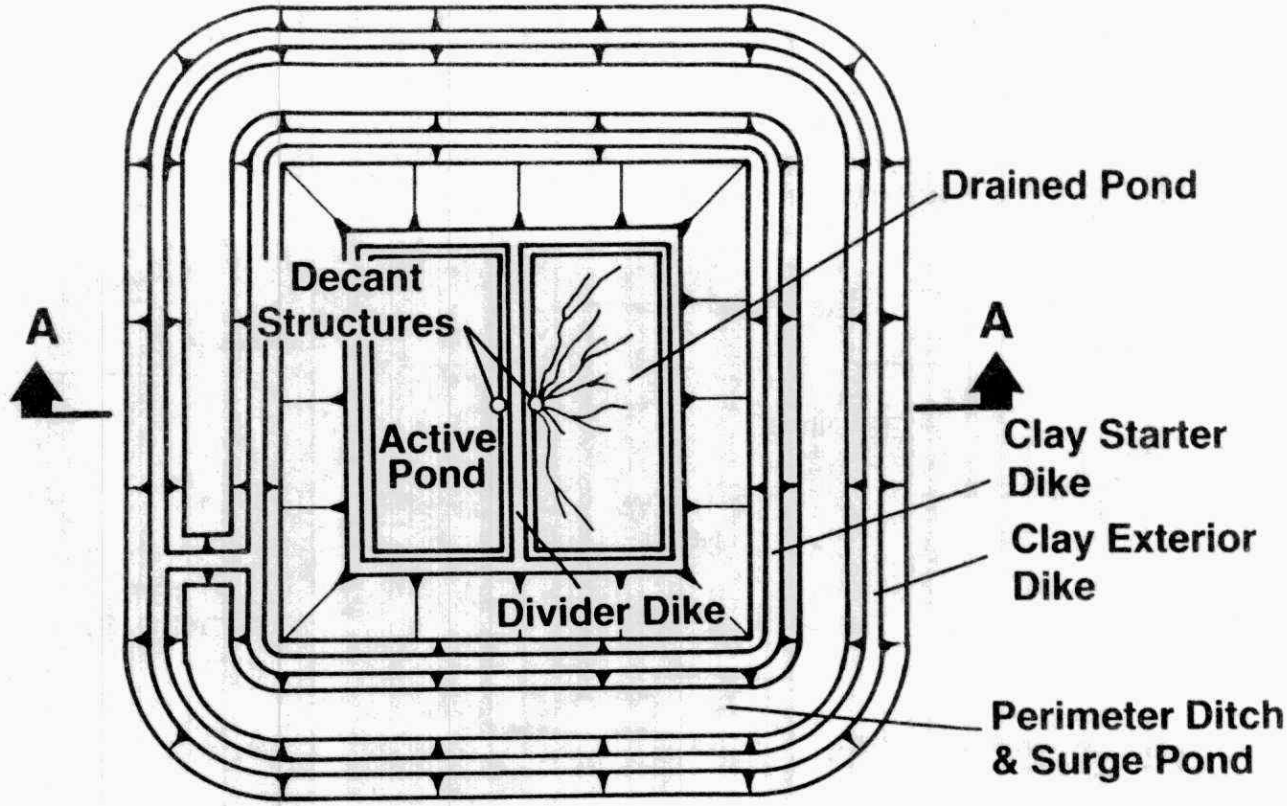
- PROJECT IMPLEMENTATION REPORT
  - Permits and Licenses
  - Environmental Impacts
  - Conditions of Approval

- ADDENDUM TO PROGRAM EA ("ROLL IN" PROCEDURE)

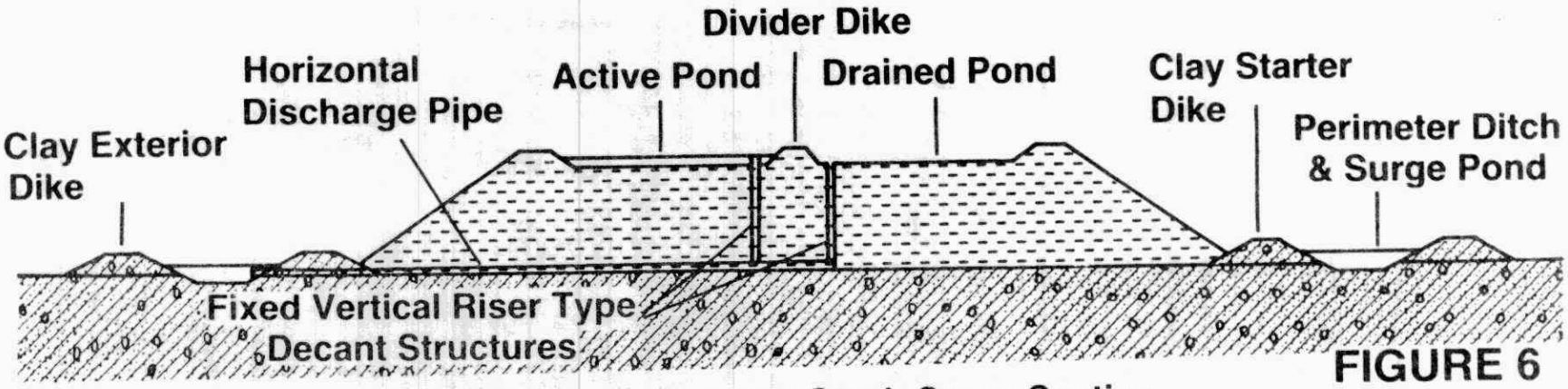


WET LIMESTONE SLURRY PROCESS

FIGURE 5



Gypsum Stack Site Plan

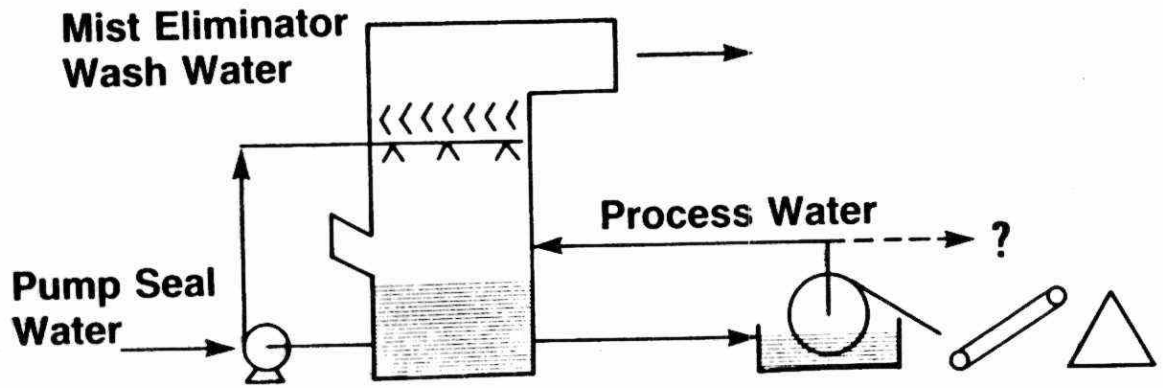


Section A – A Gypsum Stack Cross Section

FIGURE 6
Gypsum Stack

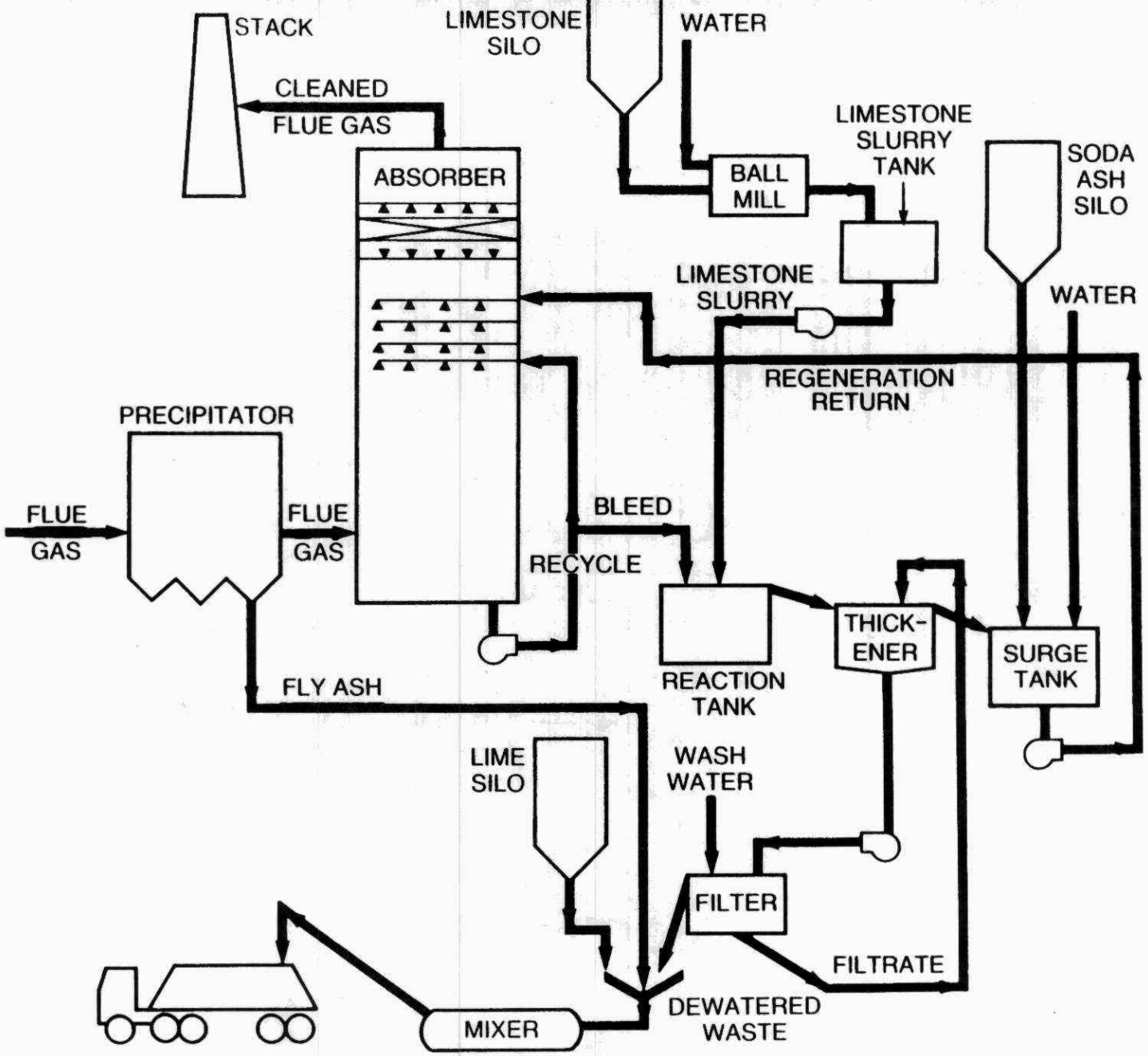
FIGURE 7

"CLOSED-LOOP" OPERATION



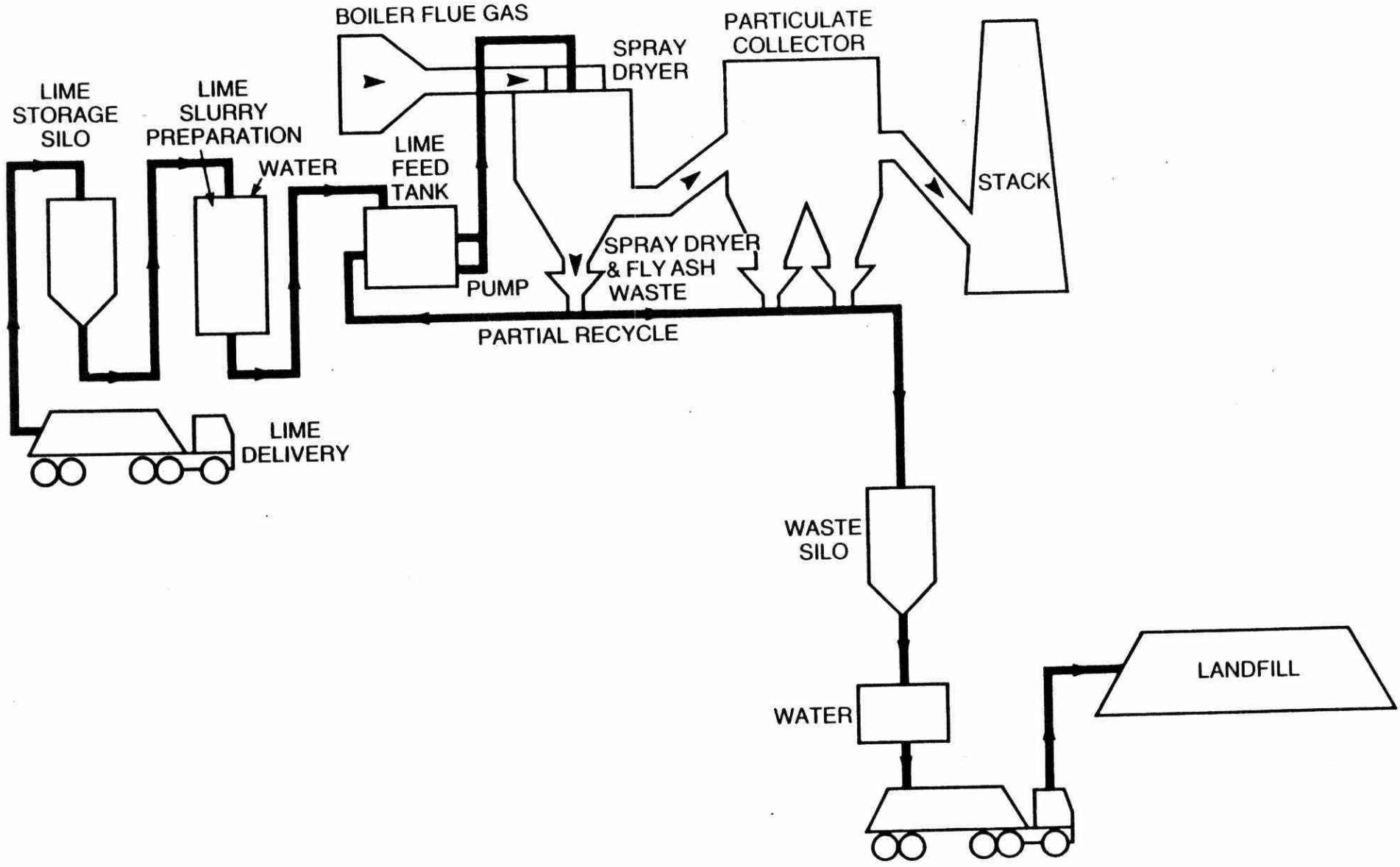
ISSUES:

- Environmental Impacts/Regulations
- Feasibility
- Process Wastewater Treatment
- Materials of Construction
- SO_2 Removal

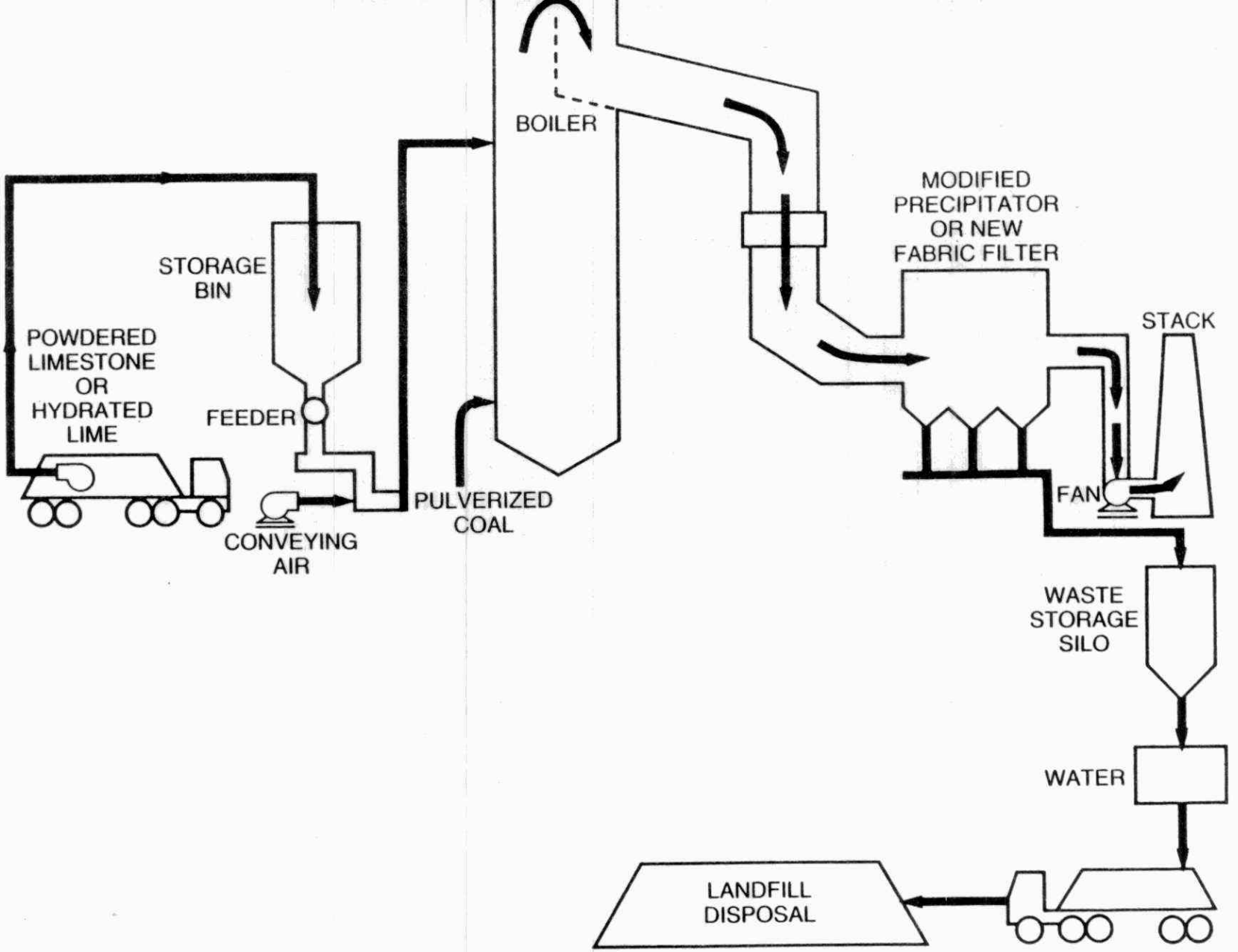


LIMESTONE DUAL ALKALI PROCESS

FIGURE 8



LIME SPRAY DRYER PROCESS
FIGURE 9



LIMESTONE FURNACE INJECTION PROCESS
FIGURE 10

FIGURE 11

WASTE MANAGEMENT - WHAT ARE THE OPTIONS?

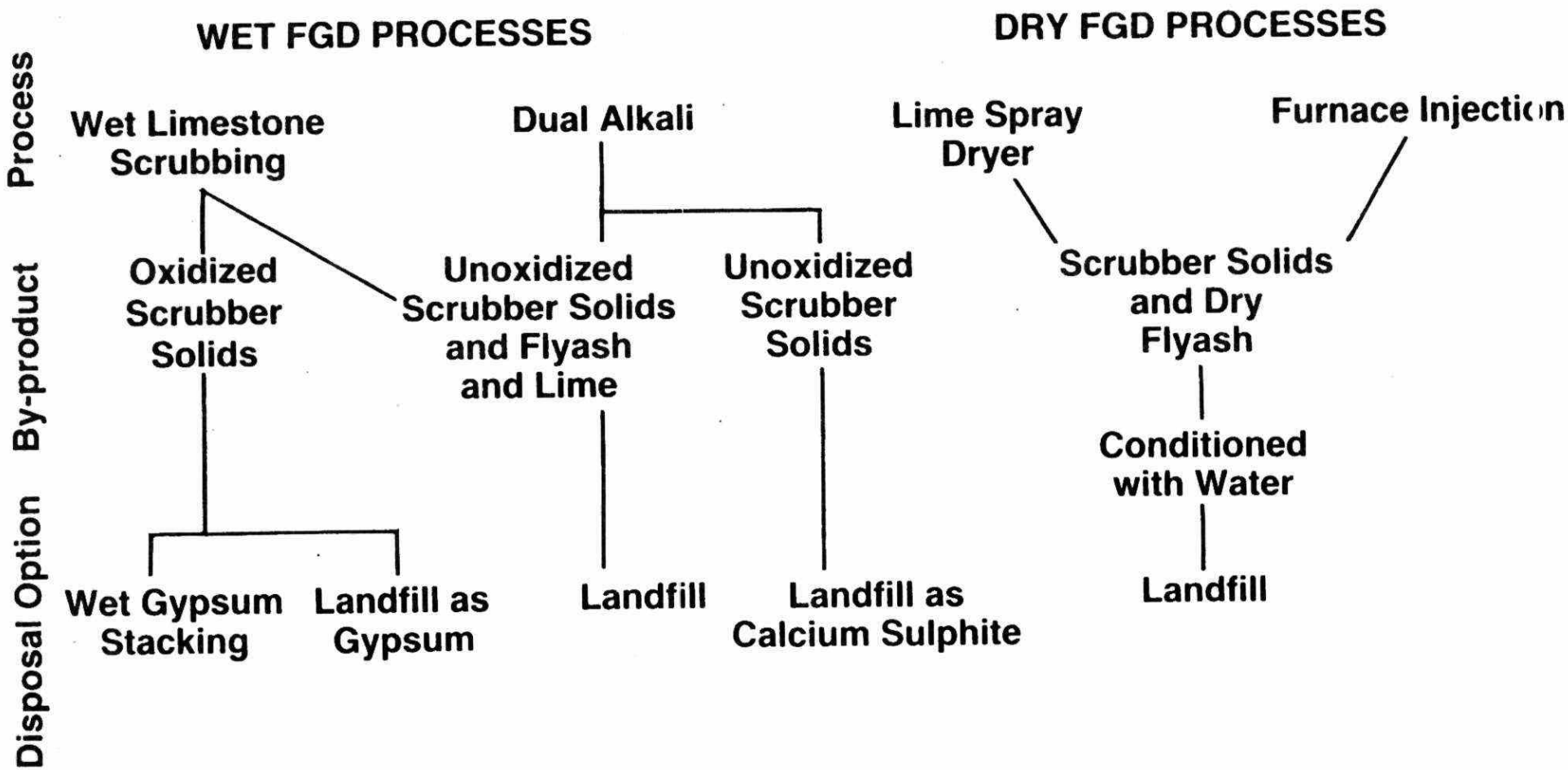


TABLE 1
CONTROL OPTIONS

- **REDUCE COAL USE**

  CONSERVATION
  HYDRAULIC / NUCLEAR GENERATION
  IMPORT ELECTRICITY
  REDUCE EXPORT SALES
  PARALLEL GENERATION

- **REDUCE FUEL SULPHUR LEVELS**

  GAS / LOW SULPHUR OIL
  LOW SULPHUR COAL
  COAL WASHING

- **INSTALL TECHNOLOGY**

  NO_x CONTROL TECHNOLOGY
  SO_2 CONTROL TECHNOLOGY

TABLE 2

HIGH CAPITAL COST HIGH REMOVAL EFFICIENCY SYSTEMS

- LIMESTONE SLURRY PROCESSES
- LIME SPRAY DRYER PROCESS
- LIMESTONE DUAL ALKALI PROCESS

LOW CAPITAL COST LOW REMOVAL EFFICIENCY SYSTEMS

- FURNACE LIMESTONE INJECTION

TABLE 3

TYPICAL PHYSICAL CHARACTERISTICS OF FGD WASTES

PROCESS	PERMEABILITY (Cm/s)	UNCONFINED COMPRESSIVE STRENGTH (MPa)
1) WET LIMESTONE SLURRY PROCESS		
- SULPHITE WASTE-FIXATED	10^{-7}	0.23 - 0.40
- DISPOSAL GYPSUM	10^{-4} - 10^{-5}	N.A.
2) DUAL ALKALI		
- SULPHITE WASTE - FIXATED	3×10^{-6}	0.40
3) LIME SPRAY DRYER		
- WATER ADDESS	2.6×10^{-5} - 9.6×10^{-7}	0.8 - 9
4) FURNACE LIMESTONE INJECTION		
- LIMESTONE SORBENT	2.9×10^{-5}	0.54
- LIME SORBENT	NA.	0.28

NA. Not Available

TABLE 4
FGD PROGRAM EA -
WASTE DISPOSAL REQUIREMENTS

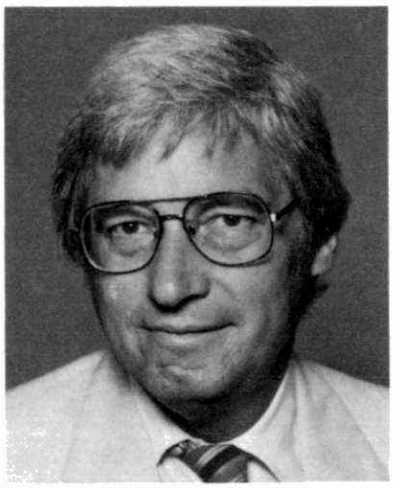
WASTE DISPOSAL AREA REQUIREMENTS (Ha)			
PROCESS	NANTICOKE	LAMBTON	LAKEVIEW*
LIMESTONE INJECTION FURNACE (LIF)	209	156	72
LIME SPRAY DRYER (LSD)	152	114	53
LIMESTONE SLURRY (LS)	152	130	50
LIMESTONE DUAL ALKALI (LSDA)	143	110	50

*AT NANTICOKE G.S.

TABLE 5
TYPICAL FGD WASTE LEACHATE CHARACTERISTICS

COMPONENT	MOE HAZARDOUS WASTE LEACHATE QUALITY CRITERIA (REG. 309) (mg/L)	LEACHATE FROM LOW EFFICIENCY FGD PROCESSES (1) (mg/L)	LEACHATE FROM HIGH EFFICIENCY FGD PROCESSES (2) (mg/L)
ARSENIC	5	<0.001	<0.005-5.80
BARIUM	100	<1	<0.005-0.125
BORON	500	<0.05-0.11	5.86-97.8
CADMIUM	0.5	<0.0002-0.0001	<0.01
CHROMIUM	5	<0.1-0.1	<0.01-0.13
CYANIDE (FREE)	20	<0.04	—
FLUORIDE	240	0.4-0.8	1.4-7.0
LEAD	5	<0.005	<0.05
MERCURY	0.1	<0.0002-0.0003	<0.001-0.021
NITRATE + NITRITE	1000	0.023-0.037	—
NITRITE	100	0.14-0.19	—
PCBs	0.3		—
SELENIUM	1	<0.001-0.005	<0.005-3.1
SILVER	5	<0.0005-0.0005	0.0005-0.012
URANIUM	2	<0.05	0.003-0.095
SULPHATE	NQ	—	1560-42400
SULPHITE	NQ	—	1-12900
CHLORIDE	NQ	—	3-140
CALCIUM	NQ	—	4.32-1090

NOTE: — NO DATA REPORTED
NQ NO LIMIT QUOTED

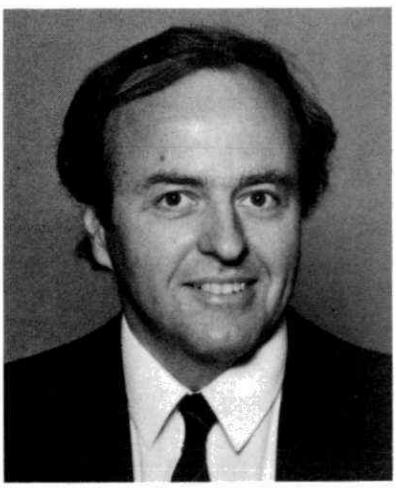


Moderator: J. Bishop, Director,
Water Resources Branch,
Environment Ontario, Toronto

N. Borodczak, Assistant Director,
Water Resources Branch,
Environment Ontario, Toronto

C.D. McKenzie, Ontario Petroleum
Association, Toronto

G. Sherbin, Ontario Region,
Environmental Protection Service,
Environment Canada,
Toronto, Ontario



Dr. D.J. Hallett, Committee
Chairman
and President, ELI Eco
Laboratories Inc., and ELI Eco
Technologies Inc.,
Rockwood, Ontario

D. Clough, Municipal Engineers
Association of Ontario, Toronto

M. I. S. A.

by

N. Borodczak, Water Resources
Branch, Environment Ontario
Toronto

MUNICIPAL - INDUSTRIAL STRATEGY FOR ABATEMENT

ENVIRONMENT ONTARIO'S NEW PROGRAM FOR CUTTING TOXIC WASTES

MISA was announced by

Ontario Environment Minister

Jim Bradley

in June, 1986

Its goal: the virtual elimination of toxic contaminants discharged into Ontario waters.

WHAT MISA DOES

MISA is a regulatory program. It will control and reduce the amount of toxic contaminants in all industrial and municipal effluents.

WHAT MISA CONTROLS

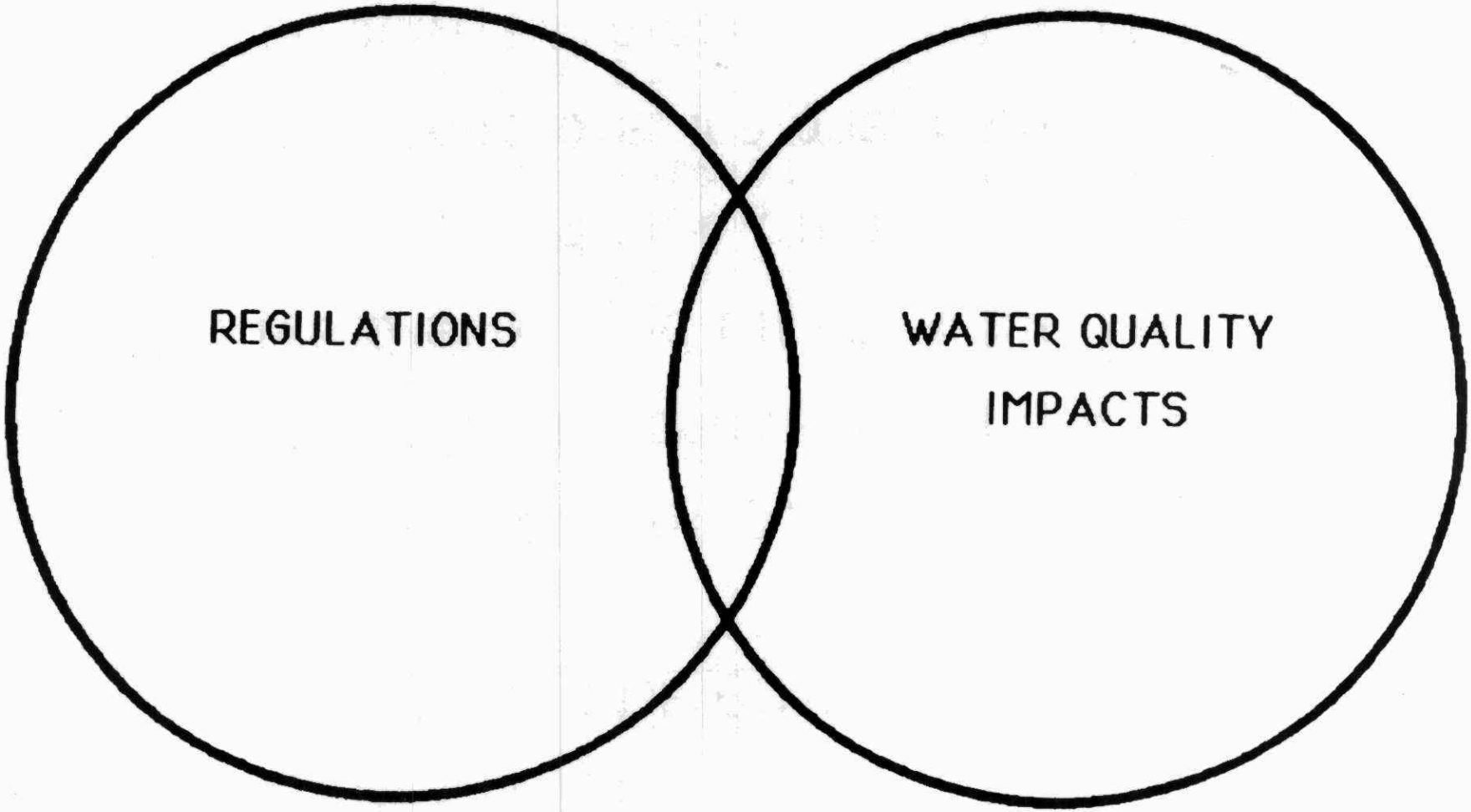
MISA introduces control of persistent toxic contaminants, like chlorinated organics.

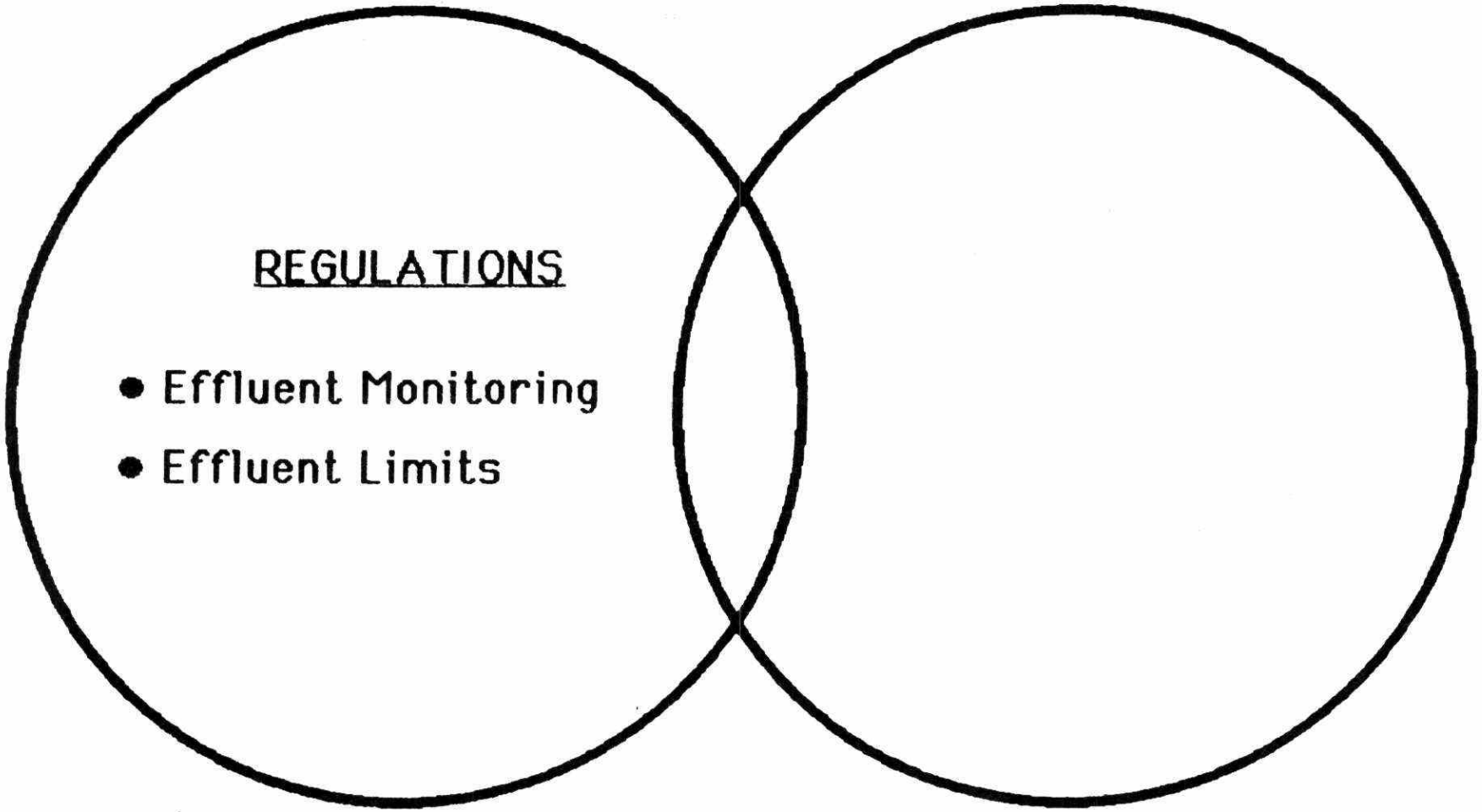
Controls continue on conventional pollutants, like suspended solids.

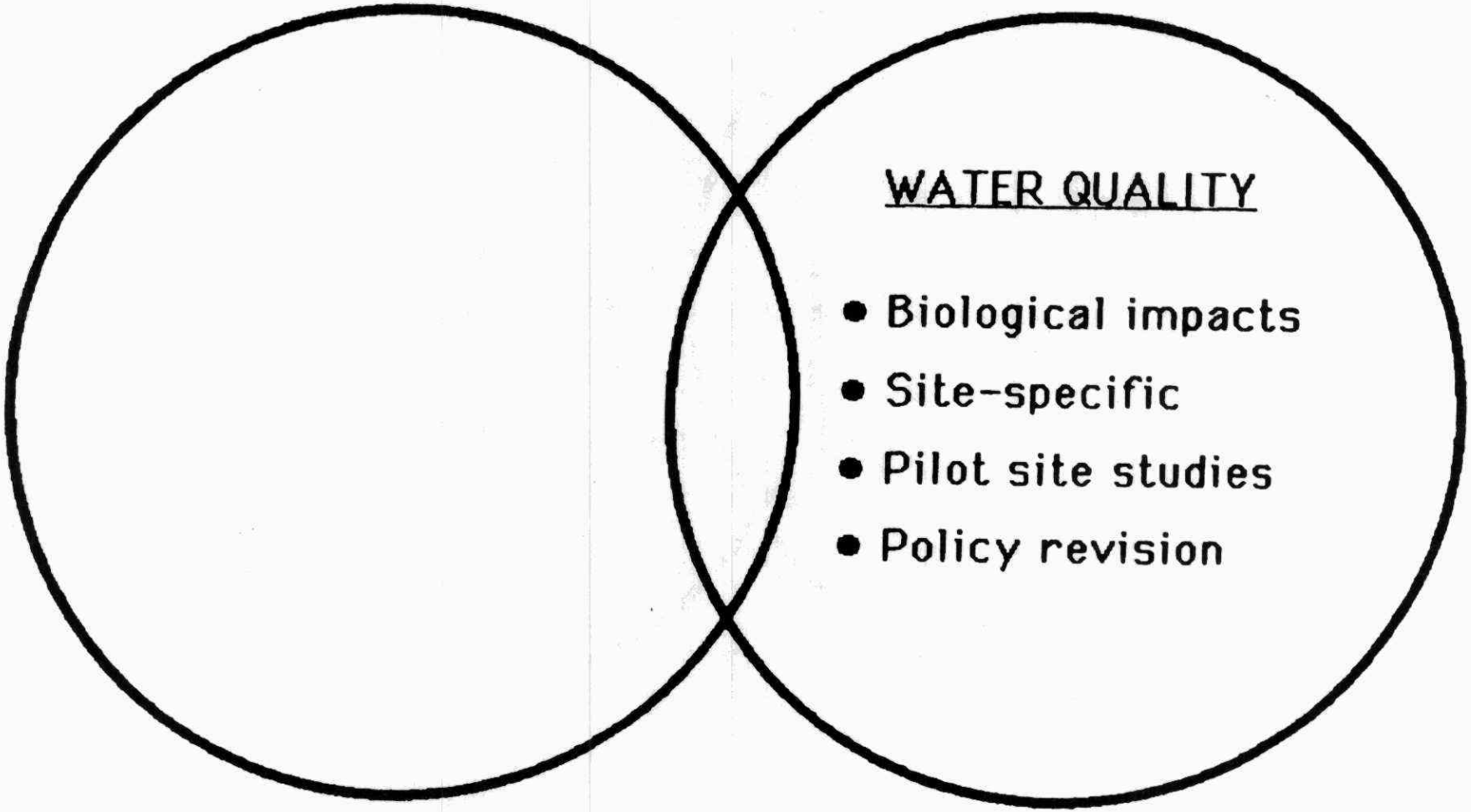
METHODS OF CONTROL

MISA sets technology-based limits on amounts and concentrations of toxics discharged directly by industries and municipalities. Further controls are based on water quality impacts.

COMPONENTS




REGULATIONS
• Effluent Monitoring
• Effluent Limits


WATER QUALITY
• Biological impacts
• Site-specific
• Pilot site studies
• Policy revision

WATER QUALITY IMPACT - BASED EFFLUENT REQUIREMENTS

- Water quality impact assessment will set effluent limits
- Site Specific
- Effluent limits based on aquatic and human health effects
- Considers both concentration and loading effects

MONITORING REGULATION

- Requires dischargers to identify and measure concentrations and amounts of toxics in their effluent

- Specifies sampling, analytical and data reporting protocols

- Self-monitoring program to be audited by MOE

LIMITS REGULATION

- Specifies allowable concentrations and amounts of toxic pollutants for each discharger

- Specified levels to be based on BAT - Best Available Technology - economically achievable

- Limits to be developed for each sector

REGULATION DEVELOPMENT

SECTOR	REGULATION STATUS
PETROLEUM REFINING	-DRAFT REGULATION SCHEDULED FOR PUBLIC REVIEW IN JUNE AND PROMULGATION BY AUGUST -MISA PRIORITY POLLUTANTS LIST REPORT FOR PUBLIC REVIEW IN JUNE
ORGANIC CHEMICALS PULP AND PAPER MINING & MINERALS IRON & STEEL	-IN VARIOUS STAGES OF PRE-REGULATION CONSULTATION AND MONITORING
HYDRO INORGANIC CHEMICALS	-TECHNICAL COMMITTEE STARTS BY END OF JUNE
MUNICIPAL	-40 STPs SURVEY AND SEWER-USE CONTROL STRATEGY DEVELOPMENT IN PROGRESS

THE PUBLIC ROLE

- White Paper public review and comment
- MISA Advisory Committee reviews draft regulations and makes recommendations
- Formal period for public review of draft regulations
- Complete access to contaminants discharge data, compliance status and abatement progress

NATIONAL PERSPECTIVE

MISA IS STRONGLY SUPPORTED BY TECHNICAL/SCIENTIFIC RESOURCES OF ENVIRONMENT CANADA.

ENVIRONMENT CANADA'S INVOLVEMENT BRINGS:

- a national perspective to MISA's implementation
- transfer of pollution control measures to the rest of Canada

TRANSFER OF MISA NATION-WIDE

IMPLICATIONS:

- First monitoring regulation (for Petroleum Refining Sector) has implications for refineries in other provinces

- Promulgating regulations for other sectors in Ontario will have implications for other provinces

TRANSFER OF MISA NATION-WIDE

ACTIONS:

- Environment Ontario is prepared to conduct workshops, briefings, etc. on MISA across Canada

- Environment Ontario would sponser a national workshop under auspices of CCREM

ENVIRONMENT CANADA PARTICIPATION IN MISA

by

G. Sherbin, Pollution Abatement Division,
Environmental Protection, Ontario Region,
Environment Canada, Toronto

I want you to know that Environment Canada is:

* Involved.

* Concerned.

That we have our expectations.

And that we certainly have been making progress.

What we are involved in, concerned about, have our expectations for and are continually making progress in ... is the Ontario Ministry of Environment's MISA Program.

We are involved in it and that, at the request of the Organizing Committee, is what I'm going to talk to you about today.

As you know, MISA stands for a bold new initiative in pollution abatement.

When the Province established the MISA program, it asked Environment Canada for assistance. We acknowledge that MISA is a major pollution abatement initiative. We are more than willing to provide our acquired expertise on the development of monitoring requirements ... and effluent limits for municipal and industrial discharges.

Especially so because we know that MISA's regulatory controls should make a significant contribution to the eventual elimination of toxic substances in discharges to the Great Lakes. That objective, is a top priority for Environment Canada's Ontario Regional office.

MISA, we feel, will make a major contribution to achieving Canadian commitments under the Great Lakes Water Quality Agreement.

The Province also wanted our assistance in providing advice on the implications of the program's regulatory agenda ... implications to other provincial and territorial abatement programs in the country.

It should come as no surprise to the majority here that Environment Canada was willing to provide that advice ... or any other advice requested.

Involved in that advice, to date, are thirteen person years and the commitment and expertise of various Environment Canada Branches, Programs and Services.

These include:

- The Ontario Regional Office
- Ottawa's Industrial Programs
- Technical Services and
- The Economic Anaylses Branch
- The Burlington Wastewater Technology Centre and
- The National Water Research Institute.

The expertise and advice that we are offering takes different forms.

For example ... the Ontario Regional Office of Environment Canada is coordinating the technical people involved in the program. As well, the office is participating in MISA negotiations with industry.

Ottawa's Industrial Programs Branch is providing national expertise on pollution abatement control for the various industrial sectors and the municipal sector.

The Technical Services Branch and the Burlington group are offering analytical and technology development support while the Economics people will provide information on economic implications.

The National Water Research Institute is providing advice on the possible effects of the program on water quality.

We are involved in MISA ... at the Province's request ... and with their blessing.

We became involved because Ontario was concerned ... as were we. The Province, very early on in our deliberations with them ... expressed concerns about MISA's Regulatory Agenda to Canada-wide water pollution abatement requirements.

There are no territorial imperatives here. We want to help, we want to provide assistance.

In fact, it is our intention to help Ontario promote, nationally, the MISA program objectives.

For many good reasons ... not the least of which is the fact that MISA complements a new federal initiative on Environmental Legislation. This federal initiative is the Canadian Environmental Protection Act, otherwise known as CEPA.

At the same time that Ontario was introducing MISA, Environment Canada was preparing a major overhaul of many of the Federal Government's Environmental Laws.

Our Minister of the Environment, Tom McMillan, tabled a draft Environmental Protection Act in the House of Commons in December, 1986.

It's an important effort to consolidate the Environment Minister's authority under one environmental act.

It's important because the majority of Canadians believe that pollution has a direct effect upon their health. In fact, we have surveys that show that toxic chemicals rank right up there with unemployment and threats to world peace as three main issues of greatest concern.

The Canadian public wants governments to provide leadership on environmental issues. The vast majority ... one survey indicates up to ninety percent of the people ... believe that their own health and that of their families is affected by pollution.

The Federal Government's draft Canadian Environmental Protection Act is a major step in fulfilling the goal of a pollution-safe society.

The proposed Act focuses on managing toxic chemicals through their full life cycle. That cycle includes manufacturing, transportation, use, storage and, ultimately disposal of these toxic chemicals.

Prevention ... not after-the-fact remedies ... is the emphasis of this proposed Act.

It would mean that the Minister of Environment, in conjunction with his provincial colleagues, could take direct action at any point in the life cycle of a chemical substance ... should the need arise.

There's authority under this proposed Act. The authority to control the introduction of chemical substances, new to Canada, into Canadian commerce.

And the authority to obtain information on and require testing of not only new substances but substances already in Canadian commerce.

There are also a number of important provisions under the proposed Act.

The proposed Canadian Environmental Protection Act has provisions to create national guidelines and codes for environmentally sound practices. And provisions for creating objectives and setting desirable levels of environmental quality.

Also proposed are provisions for ... controlling sources of air pollution in Canada where there is danger to the environment and human health ... where a violation of an international agreement would result ... or if that air pollution affects another country.

There will be provisions for regulations governing federal works. It will provide for regulations to protect federal lands and waters, especially where existing legislation, administered by federal departments or agencies, does not provide for making regulations which protect the environment.

Finally, the proposed Act will also provide for the control of nutrients, such as phosphates, which interfere with the use of water by all life ... human, animal, fish or plant.

The proposed Act will recognize the rights of Canadians to a healthy environment. It commits the federal government to cooperate with provincial and territorial governments ... in consultation with all Canadians.

The protection of the Canadian environment is a responsibility shared by all levels of government as well as by industry, labour and individual Canadians.

The Canadian Environmental Protection Act acknowledges this shared responsibility. It will give the Minister of Environment the authority to conclude, with the approval of the Federal Cabinet, agreements with provinces and territories with respect to the administration of the Act.

It means cooperation. And it is feasible, workable and desirable. Our experiences working with MISA have shown that a shared spirit of responsibility can result in a shared spirit of cooperation.

And cooperation, not overlapping is the key. The federal government has designed a number of ways to avoid overlapping legislation with the administration of Provincial Statutes.

We believe that there is a consensus among all the country's Environment Ministers that all governments must do a better job when dealing with an issue as complex as toxic chemicals.

We must work together and do it in a way that avoids duplication but delivers protection ... all in a cost effective manner as well.

The Canadian Council of Resource and Environment Ministers, otherwise known as CCREM, has become an important forum for such intergovernmental consultation.

To date, the Council has agreed that:

- A framework is needed in Canada to ensure adequate control of chemicals throughout the life cycle ... from cradle to grave.
- And that putting such a framework together is the responsibility of all Canadians.

It's not just the responsibility of one level of government or another. It's not even the sole responsibility of government.

Our proposed Act is designed around this philisophical framework. We are streamlining the federal environmental protection requirements. And we're doing it in response to concerned Canadians. We are convinced that the public will be more receptive to federal and provincial governments each exercising their environmental protection responsibilities in ways which complement each other.

We're convinced of this because we have involved the public since the proposed Act was first introduced. So far, we have received and analyzed more than three hundred submissions under our extensive Public Consultation Program.

We've read, listened and studied ... and reacted. The next draft of the Bill will incorporate suggestions and changes.

We feel sure that it will broaden and strengthen the Bill.

Here's one example of how ... the new draft includes details on a suggestion for third party review of confidential business information.

Another idea which was adopted ... a mechanism, whether it's a consultative committee or an advisory council representing stakeholders, will be involved in developing regulations.

We listened to individuals and we listened to other governments.

For example, if we undertake an initiative which will have implications for a province ..., we'll consult with that province.

The proposed Bill would allow for intergovernmental agreements detailing how we can work together in the administration of this important legislation.

Take the consultative or advisory committee ... add the obligation to consult ... and the result is a federal law which should provide the necessary checks and balances to guard against duplication.

I'm sure that you will be hearing more about the Canadian Environmental Protection Act soon. The Minister intends to table it in Parliament, for first reading, before the end of the summer sessions.

By participating in MISA, we have gained an invaluable experience in federal-provincial cooperation, so necessary for the smooth functioning of successful environmental protection programs.

Our participation in MISA is a top priority. We hope that the results of MISA can be integrated into the framework of our new Bill.

I should make it clear, however, that we're not clear on everything just yet.

For example, it is not yet clear on what procedures will ultimately be adopted for the updating and development of national guidelines and codes for toxic discharges.

But it is clear that there is widespread interest in Ontario's MISA program; and it's clear that Environment Canada is committed to support this bold, new initiative. Athough I have dwelt ... and I don't think

I'll get any disagreement here ... at great length ... with the cooperation experienced between Environment Canada and the Ontario Ministry of Environment ... such cooperation has not been limited to governments.

Industry too has been deeply involved.

For instance ... the Petroleum Refining Sector, represented in the Joint Technical Committee by the Ontario Petroleum Association was able to demonstrate that its sector is exceedingly close to the MISA goal of virtual elimination of toxics in their waste waters.

Their past environmental efforts, as well as the expenditures involved, have also put this sector in a good position for dealing with effluent control limits. Limits which are part of the MISA program.

And there's the Organic Chemical Sector as well. It recently completed a pre-regulation monitoring program. The Joint Technical Committee for this particular sector has also reached a consensus on the purpose and guiding principles for six issues. These issues, initially raised by the Canadian Chemical Producers Association, will be dealt with under the MISA program.

The Pulp and Paper Sector has been actively involved. Represented by the Ontario Forest Industries Association, it volunteered to carry out an ambitious pre-regulation monitoring program.

As well, it was agreed to set up a Government/Industry Analytical Working Group to look at standardizing analytical methods for non-conventional organics, commonly found in pulp and paper mill waste waters.

Mining, as well as the Iron and Steel Sectors are also getting involved. They're working on designing and setting up their own pre-regulation monitoring programs.

We need a healthy, safe environment to lead a healthy, safe life.

We know that pollution can jeopardize our environment, our health and our lives. And we know that we have to do something about it.

The federal government has taken a leadership role in the establishment of national codes and guidelines for environmental quality. We've taken a leadership role in promoting a social and economic climate in which environmental concerns will have a place in economic decisions.

We've taken a leadership role but we can only continue to be a leader with your cooperation.

I'd like to thank the Province for asking Environment Canada to join them in MISA ... and I'd like to thank the Conference Organizers for asking me to join you here today.

THE ROLE OF THE MISA ADVISORY COMMITTEE

by

D.J. Hallett, Chairman, MISA Advisory Committee

MISA ADVISORY COMMITTEE (MAC) Terms of Reference

by Order in Council pursuant to the Environmental Protection Act, the MISA ADVISORY COMMITTEE is to provide advice to the MINISTER OF THE ENVIRONMENT in accordance with the "Municipal-Industrial Strategy for Abatement" specifically:

(a) to review draft regulations relating to monitoring and effluent limits prepared by nine sectoral technical committees;
(b) to liaise and work with the technical committees;
(c) to provide advice and recommendations to the Minister on the content of the regulations; and
(d) to provide advice with respect to such other related matters as the Minister may prescribe.

MISA ADVISORY COMMITTEE MEMBERSHIP

MAC - a group of independent experts providing the MISA process and the Minister of the Environment with a "third party" opinion, emphasizing environmental protection,

CHAIRMAN *Dr. Douglas J. Hallett*

- environmental toxicologist; biochemist; analytical chemist
- President ELI Ecologic Inc., Toxic Chemical Specialists
  ELI Ecolaboratories Inc; ELI EcoTechnologies Inc.
- Former Senior Scientific Advisor, Environment Canada

VICE CHAIRMAN *Toby Vigod*

- environmental lawyer
- Counsel, Canadian Environmental Law Association
- specialty - toxic chemical and pesticide regulation

MISA ADVISORY COMMITTEE MEMBERSHIP

Monica Campbell

- Doctoral Candidate, Toxicology, UofT, focussing on biological markers of environmental contaminants
- formerly researcher with the Pollution Probe Foundation

Harvey Clare

- retired Executive, Environmental Protection Coordinator, Imperial Oil
- past president and founding member PACE and former treasurer, Conservation Council of Ontario

Dr. Paul Hebert

- Professor of Biology, Great Lakes Institute, University of Windsor
- focussing on technical and policy aspects of population biology particularly relating to toxic contamination

MISA ADVISORY COMMITTEE MEMBERSHIP (continued)

James W. MacLaren

- Consultant, environmental engineering and policy
- distingushed member and executive of Engineering associations
- recently a Commissioner on the "Inquiry for the Canadian Government on Federal Water Policy"

Dr. Donald MacKay

- Professor, Chem Eng., Applied Chemistry, UofT, Environmental Studies
- focussing on research of environmental impacts and ecosystem modelling, dynamics of organic contamination and aquatic based pollution control methods

Kai Millyard

- researcher, Pollution Probe Foundation
- focussing on research, policy, and public education on a wide range of environmental issues: esp. drinking water quality, Great Lakes pollution, hazardous waste management

MISA ADVISORY COMMITTEE MEMBERSHIP (continued)

Representing the **Ontario Petroleum Association** during the discussion of the Petroleum Refinery Effluent Monitoring Regulation

Ray Shaver

- Manager, Government Relations, Texaco Canada Inc.
- former chemist, refinery department (to 1970) and Coordinator, Corporate Environmental Affairs (1970 - 1980)
- former president of both PACE and OPA, current board member
- current Director, Institute for Political Involvement

MISA

Goal:

- virtual elimination of loadings of persistent toxic contaminants

Objective:

- controls through 'monitoring' and 'effluent limits' regulations

PETROLEUM REFINERY EFFLUENT MONITORING REGULATION

- The monitoring is "to reflect all conditions of operation, including normal and upset conditions, within a standardized framework of sampling and analytical quality assurance, quality control and audit".
- The data base will be used to evaluate current effluent water quality, and to determine the level of further treatment required to meet specific performance standards and water quality requirements.
- Effluent limits regulations will supercede the monitoring regulation and will include ongoing or amended monitoring requirements.

MISA ADVISORY COMMITTEE REVIEW

- focus on end result of monitoring phase
- concern for scientific validity; meaningful process & results; economy
- focus of review on chemical monitoring and inter-relationships of detection levels, test result variability, effluent water flow and the calculation of loadings and chronic toxic effects
- concern for the development of analytical methods to yield meaningful results for the detection of compounds of concern and for the determination of loadings and toxic effects

- specific recommendations for the Petroleum Refinery Effluent Monitoring Regulation
- recommendations for research and MISA program refinement and development

- concern for equal and sequential application of recommendations to all sectors

COMPARISON OF ACUTE & CHRONIC EFFECTS AND LAKEWIDE IMPACTS

Class	Pollutant	Acute Effect (conc.)	Chronic Effect (conc.)	Lakewide Impact (loading)
Conventional Parameter	-BOD	10 ppm	-	100-1000 T/yr
	-Chloride Ion	10 ppm	-	100-1000 T/yr
	-Phosphorus	10 ppm	-	100-1000 T/yr
Non-Persistent Toxic Chemical	-Benzene	10 ppm	-	100-1000 T/yr
	-Xylene	10 ppm	-	100-1000 T/yr
Persistent Toxic Chemical	-PCB's	-	100 ppt	750 kg/yr
	-BApyrene	-	10 ppt	75 kg/yr
	-Mercury	-	100 ppt	750 kg/yr
	-Lead	-	100 ppt	750 kg/yr

MISA ADVISORY COMMITTEE REVIEW

ROUTINE MONITORING

- quarterly monitoring basis for the calculation of loadings
- provide measure of loadings and assessment of exposure to persistent toxic contaminants
- levels of detection major concern
- effluent flow rates in some refineries such that 10 ppb detection level would not provide useful data for calculation of significant loadings in 100 to 1000 kg/year range

- Recommendation
  - *lower standard detection level from 10 ppb to 1 ppb or MDL for chemicals of concern*
  - *-research further reduction of MDL's by anayltica. methodology development and validation*

MISA ADVISORY COMMITTEE REVIEW

LISTING / DELISTING MECHANISM

- critical aspect of regulatory process
- data assessment to address:
  - -elimination or addition of parameters; assessment of detection levels, sampling frequencies
  - -need for analytical method development or validation
  - -identification of chemicals for more intensive scrutiny
  - -estimation of chemical loadings to the environment and associated confidence limits

- Recommendation:
  focussing of resources to address this immediate priority: develop mechanism within six months

MISA ADVISORY COMMITTEE REVIEW

ACUTE TOXICITY TESTING

- toxicity tests valuable as a means of detecting presense and effects of deleterious compounds
- increasing movement towards comprehensive toxicity assessment programs, similar to USEPA

- Recommendation
  development of comprehensive toxicity assessment program for Ontario and reflection in MISA regulations
  - immediate move to validated Daphnia spp. test program
  - research program to develop validated test protocols for broader range of test organisms and in static and flow-through conditions

NIBA ADVISORY COMMITTEE REVIEW

CHRONIC TOXICITY TESTING

- chronic toxicity tests aim to assess biological effects of exposure to compounds at low concentrations over extended periods of time
- lakewide ecological effects can be caused by the aggregated loading of pollutants which in effluents are perceived to appear in minute quantities
- current chronic toxicity estimated by extrapolation of results of acute toxicity studies

- Recommendation
  Research program to develop validated chronic toxicity tests over 2-year period; for incorporation in subsequent monitoring and effluent limits regulations

MISA ADVISORY COMMITTEE REVIEW

SPILLS

- spills may contribute significant chemical loadings to the environment

- Recommendation
  reports to Ministry under Spills Bill should be integrated into MISA reporting program and available in satisfactory detail to provide useful information for the calculation of loadings

MISA ADVISORY COMMITTEE REVIEW SUMMARY

- positive impact on process
  - an important expert 'third party' opinion on the direction and effectiveness of MISA program and the adequacy of the proposed regulations
  - focus on scientific integrity of the program and the assessment of ecosystem effects of toxic chemicals

- recommendations accepted for implementation within the regulation and Ministry work program

- development of productive working relationship with the industrial sector and the Ministry

THE PETROLEUM INDUSTRY'S VIEW OF MISA

by

C.D. McKenzie for The Ontario Petroleum Association, Toronto

I am pleased to have this opportunity to present this paper on behalf of both the Ontario Petroleum Association and the Petroleum Association, for the Conservation of the Canadian Environment. OPA represents the petroleum industry, both refining and marketing, within Ontario. PACE has a national mandate, and provides technical support for the OPA on problems that are national in nature.

PACE, consists of eight major oil companies (table 1). Its objectives put a special emphasis on environmental protection. This is one unique area where we, in the petroleum industry, work co-operatively to seek answers to complex problems. In addition, we frequently work co-operatively with government, universities, and the consulting sector to further our knowledge and our ability to effectively control the environmental aspects of petroleum industry operations.

With respect to MISA, Ontario's Municipal Industrial Strategy for Abatement, the Ontario Petroleum Association supports the Ministry of the Environments' goal to control toxics and conventional contaminants in municipal and industrial discharges, so as to safeguard human health and the ecosystem.

This paper will present both the petroleum industry's views on MISA, and provide an overview of preregulation investiations, conducted under the supervision of government and industry technical staff.

To deal effectively with this subject in the time allotted, I will format the presentation as follows:

- Review of Trace Contaminants in Petroleum Refinery Effluents
- The Refinery Monitoring Regulation, an Overview
- The MISA process in MID-SIGHT

As background, liquid effluent quality from the petroleum refining industry in Canada has been controlled under Federal regulations and guidelines since 1974. Ontario, for our sector, has had even more stringent guidelines for many years. Effective treatment is required to satisfy the current criteria.

Liquid effluent treatment facilities at each refinery, are site specific. However, common processes are widely used. These can include two stages of oil recovery, biological treatment, storm water management and, above all, control. That's the marriage between the facilities and their operation. Facilities alone are not adequate.

Currently, effective treatment is directed at controlling the discharge of key conventional and non-conventional contaminants. A quick look at this list (table 2), of control parameters shows that we, the petroleum industry, currently have both specific monitoring requirements for a class of toxics (phenols) and a biomonitoring requirement. Phenol limits are in the parts-per-billion range. Biomonitoring (using rainbow trout fingerlings) results typically indicate that our effluents are non-toxic.

In addition to the routine 'compliance' monitoring, numerous studies of trace contaminants had been conducted for refinery effluents. The preregulation monitoring reviewed all of this work, conducted by individual Ontario refiners, by government (MOE, EPS, EPA), or by PACE, and identified

the need for a further limited variability study.

Before I review this new study, I want to highlight the key findings of these previous studies. Briefly, three conclusions stand out:

- Firstly, existing effluent treatment systems are effective in reducing and, in cases, removing trace contaminants from refinery effluents.
- Secondly, eighty percent of the contaminants on the EPA priority pollutant list were either not detected, or rarely detected in refinery effluents.
- And thirdly, those detected were generally present at concentrations below water quality criteria. Most were metals, not organics.

Reviewing all of the available studies, it was considered necessary to conduct a preregulation monitoring program at two Ontario refineries. This recognized that data were already available for most sites.

The study was a co-operative effort with a steering committee composed of technical staff from government and industry. Canviro, the prime contractor, was independently responsible for management of the project.

The overall objective of the pre-regulation monitoring program was to provide technical data to support the development of the monitoring regulation. More specifically, however, the project was focused to expand our knowledge of trace contaminants in refinery waste water treatment systems.

Specific objectives were threefold:

- Firstly, to determine if a relationship existed between trace contaminant concentrations and biological treatment plant operating conditions, such as sludge age or nitrification.
- Secondly, to assess the practicability of identifying a surrogate which could be used to indicate the presence or absence of trace contaminants.
- And thirdly, to validate or add to previous studies.

Refinery selection was biased towards older refineries. Esso's Sarnia refinery is large, complex, old, and has an optimized biotreater. Petro Canada at Oakville, is smaller and simpler. The waste water treatment plant was undergoing optimization studies, but was not fully optimized.

The sampling program involved 6-hour flow proportioned samples of influent and effluent, from the biological treatment plants at each refinery. The influent and effluent samples were separated by the hydraulic residence time of the facility.

At the same time, measurements were made to define the operating conditions of the biological treater.

The analytical program focused on contaminants, which had been identified in previous PACE studies. In addition, it included GC/MS scans, for EPA priority pollutants and some open scans.

From previous studies, we know it is not easy to do trace contaminant studies.

A comprehensive quality control and quality assurance program was maintained throughout the sampling and analysis. This included split samples, with the MOE laboratory and what might be called excessive field quality control/quality assurance.

Significant differences existed in the operating conditions of the two biological treatment systems. (As shown on table 3.) Both had approximately the same six-hour residence time, oxygen levels and operating temperatures. Relative to the Petro Canada treater, the Esso unit had a much longer solids residence time, a lower clarifier loading rate, a lower oxygen uptake rate, and lower sludge volume index. In addition, it was nitrifing.

Significant differences were also found between the biotreater influents at the two refineries. Notably, the Petro-Canada treatment plant received considerably higher concentrations of phenols, benzene, toluene, ethylbenzene, xylene and PAH's, than the Esso plant (table 4).

Despite these differences in operation of the treatment systems, and in the feed quality for the two plants, trace organics in the effluents of both treatment plants were reduced to levels both low and comparable.

No trace organics, other than phthalates, were found at concentrations higher that the detection limit, in more than half of the effluent samples at either refinery.

Phthalates are discounted because they are believed to be an artifact of the sampling.

Table 5 shows some typical values of trace organic removals in refinery waste water treatment systems.

The vast majority of compounds in the EPA prioity pollutant list were never detected in any influent or effluent stream.

Five major conclusions were drawn from these investigations:

- The data demonstrated that the biological treatment plants at both refineries sampled, were highly efficient in the removal of trace organics.
- The effluent quality at both sites was similar with respect to trace contaminants. Differences were most apparent in the concentrations of some conventional parameters and metals.
- The study could not establish a relationship between plant operation and trace organic removal.
- The results were consistent and at the good end of performance achievable, with respect to the removal of trace contaminants.
- Lastly, since both plants achieved efficient trace organic removal to low levels, no surrogate parameter could be identified for the presence of trace organics.

Concurrently with the preregulation monitoring study, a monitoring regulation was being developed for the petroleum sector. Looking at it from a technical perspective, I am certain we will have more information about the presence, or absence, of trace contaminants in refinery effluents in a year, than anywhere else. From an industry perspective, the program will generate 35,000 - 70,000 data points in the first year. It should be noted that we are not operating large treatment plants. In municipal terms, the largest is only equivalent to a 20,000 population plant.

Each plant will monitor for a variety of pollutants either daily, three times a week, monthly, or once each three years. In my opinion, the daily is most important. Provided that the well-operated facility can treat the trace contaminants, it is then most necessary to assure that the system is in control. The daily sampling does this. The balance of the program demonstrates or confirms the effectiveness of the operation with respect to the control of trace contaminants. The effluent monitoring, however, does not control. This is achieved by operational monitoring conducted by plant staff.

In addition to identifying the contaminants to be monitored, the regulation is very comprehensive with respect to:

- analytical protocols
- sampling protocols
- flow monitoring
- reporting
- monitoring of storm waters
- cooling waters

In closing, I would like to briefly summarize the Petroleum Industry's comments on MISA. Firstly, some thoughts on the monitoring regulation. As described, it is very comprehensive and onerous. It is not the last step, either. We see it as an evolving process that will, with time, be adjusted to meet our needs in Ontario. As a first step, we recognize that it is somewhat arbitrary. To reach the stage it has, where we expect it could be issued shortly, necessitated that its pieces be developed in isolation, along parallel paths, and brought together to form a final 'complete' regulation.

We have concerns about the practical aspects of the regulation. We are each, individually, comitted to comply with the regulation. However, it is a very comprehensive regulation. Until our plant staff actually implements it on a daily basis, I will not comment further on practicalities.

We do remain committed to the GOALS of MISA and committed to work with the regulation.

Looking back, could we have responded differently or better to the development of the monitoring regulation? The answer is yes. You can always do better. We were resource-limited within the time frame we worked. Timing has been the critical driving force. In response to the white paper this time last year, we indicated that the time frame was optimistic.

What are the challenges ahead, given that we have a monitoring regulation?

- Firstly, we have the practical challenge of both implementation, and,
- Secondly, of evolving a practical regulation.
- Thirdly, there is a need to develop a scientifically based, listing mechanism to adjust the monitoring frequency, in accordance with the needs for a given site.
- And finally, we have the development of an effluent limits regulation. The easy work is behind us.

In conclusion, the petroleum industry supports the MISA goal to control toxic and conventional contaminants in municipal and industrial discharges, to safeguard human health and the ecosystem.

T A B L E 1

ESSO PETROLEUM CANADA

HUSKY OIL OPERATIONS LTD.

PETRO-CANADA

PETROSAR

SHELL CANADA LTD.

SUNCOR INC.

TEXACO CANADA INC.

ULTRAMAR

T A B L E 2

CURRENT MONITORING REQUIREMENTS

CONVENTIONALS

- OIL AND GREASE
- AMMONIA
- SUSPENDED SOLIDS
- pH
- TOC

NON-CONVENTIONALS

- PHENOLS
- BIOLOGICAL MONITORING

T A B L E 3

SIGNIFICANT DIFFERENCES EXISTED IN THE OPERATING CONDITIONS OF THE BIOLOGICAL TREATMENT PLANTS

	ESSO	PETRO-CANADA
Hydraulic Residence Time (hour)	5.6	6.5
Solids Residence Time (days)	36-63	6
Disolved Oxygen (mg/l)	0.6-4.8	0.1-3.0
Temperature (°C)	27-36	36
Clarifier Surface Overflow Rate (M/D)	13.1	42.1
Sludge Volume Index (ml/g)	90	200
Specific Oxygen Uptake Rate (gO_2/g VSS. D)	0.051	0.59

T A B L E 4

SIGNIFICANT DIFFERENCES WERE FOUND BETWEEN INFLUENT QUALITY AT THE TWO REFINERIES

	ESSO INFLUENT	PETRO-CANADA INFLUENT
TSS (mg/l)	34.	57.
DOC (mg/l)	25.	45.
TKN (mg/l)	11.	21.
Phenol (ug/l)	188.	22,544.
Oil and Grease (mg/l)	11.	22.
Benzene (ug/l)	73.	1,540.
Toluene (ug/l)	27.	1,071.
Xylenes (ug/l)	467.	584.
Ethylbenzene (ug/l)	4.	122.
PAH's (ug/l)	N.D. - 79	N.D. - 2,948

TABLE 5

TRACE ORGANIC CONCENTRATIONS WERE REDUCED TO LOW LEVELS IN REFINERY EFFLUENTS - SELECTED EXAMPLES

	BIOTREATER FEED		BIOTREATER EFFLUENT	
	MEAN (ug/l)	FOD	MEAN (ug/l)	FOD
BENZENE (1)	1,540	100	ND	0
(2)	73	83	ND	50
TOLUENE	122	100	ND	0
XYLENE (1)	584	100	ND	0
(2)	467	100	ND	44
NAPTHALENE	239	100	ND	0
FLUORENE	94	100	ND	0
PHENANTHRENE	127	100	ND	0

FOD = frequency of detection above the analytical limit of detection

THE MUNICIPAL VIEW OF THE MISA PROGRAM

by

D. Clough for the Municipal Engineers Association of Ontario, Toronto

One cannot disagree with the ultimate goal of MISA to eventually eliminate toxic contaminants in Municipal discharges into the Province's Waterways. We are certain that all municipalities are more than willing to co-operate with the Province on this undertaking, as recent research indicates a real problem in this area. However, it is obvious that achievement of this goal will be costly. The proposed monitoring program, possibly more stringent effluent standards, enforcement measures, all introduce potential increases in cost. The larger areas such as Metro Toronto may very well have the necessary expertise on staff to carry out such a program, but many municipalities may need considerable help from the Province. The financial impact on all municipalities could be such that they all will seek assistance from the Province.

Presently, the M.O.E. is working on monitoring toxic contaminants in some 40 existing plants to gather information on the existing situation as to the influent and effluent content. This will give a good indication what removal takes place in a plant operating at or near design loadings and hopefully reasonably efficiently. From the information so gathered, effluent limits can be set on industrial discharges that will result in effluents from the plants that will meet quality standards in the receiving waters. The Ministry is also analysing, in a small number of plants, the air coming off air degritters and aeration tanks to ascertain what organic toxics are stripped off. Using the information on influents and effluents along with the analysis of the sludges, an environmental audit of a plant emerges. It is to be hoped that with the collection of such information, the M.O.E. will work closely with the municipalities to formulate the policies to monitor and regulate discharges. The Municipal Engineers' Association (MEA) has been given the responsibility

of providing the municipal input to the MISA program along with the Association of Municipalities of Ontario (AMO). Some concern has been expressed that closer liaison between these two associations is needed if the view of the municipalities is to be effectively presented. It is important that municipal bodies funnel any concerns with regard to technology, policing, costs, etc. to the MEA for discussion with the M.O.E.

There are many thousands of industries discharging to municipal systems in the Province. The monitoring of these industries has not, to our knowledge, been fully discussed between the M.O.E. and MEA. This is a problem that must be settled very shortly. The MISA program suggests that industries discharging directly to a watercourse will be required to monitor their effluents, for toxic contaminants, at their own expense. However, MISA does not say what is to be expected of industry sending their wastes to a municipal sewage system. In our view, it is essential that the Province make it mandatory that all industries, including those discharging to sewer systems, monitor their effluents in the same manner as those discharging directly to streams. With such a requirement, municipalities would then be able to enact and enforce by-laws to control such wastes. Industrial Waste Control staff would have the knowledge of what individual industries are apt to discharge and could test for more specific toxic contaminants. It would also give the public body information relative to the level of organic pollution that requires pre-treatment at the source. We strongly believe that all industry should be made to do this pre-treatment, that it is the only fair and equitable solution. The householder should not have to pay the high costs necessary to improve wastewater treatment plants in order for them to try to treat these wastes. It will also be interesting to see, from the MISA testing program, how effectively the plants can handle organic toxics. It is more than possible that most of them will pass through into the receiving waters, be flashed off with the air in aeration tanks or end up in the sludge, which then has to be disposed of by incineration or landfill. None of these results is acceptable.

It would appear that if changes are not made in the program as we understand it, any contaminants found in treatment plant effluents in excess of the limits to be set by the Ministry, will have to be traced back to their source by the Municipality. This would be an extremely difficult process and very expensive. The extensive sampling and analysis required to trace these contaminants back to their source, at a cost of at least $1,500.00 per sample, plus labour, would cost a large municipality like Metro hundreds of thousands of dollars, if not millions. This cost should and must be borne by the industry that generates them. The best course is to treat them at the source. We would re-iterate the most reasonable, the most economical and the fairest way is for all industry to sample and test for such contaminants in their own discharges.

Even with this done, the municipality will still be faced with the cost of monitoring its own discharges from its own treatment plants. In order to meet the limits set, we would anticipate the Ministry will set schedules for each plant depending on the size of the plant, and to some extent on the ability of the receiving waters to assimilate some contaminants.

The question of the ability of the Municipality to make available the necessary capital money required to upgrade the plant, where needed, must also be addressed.

In order to police an entire municipality, continual checks will have to be made to ensure that industrial plants are in fact abiding by the regulations. This will result in considerable cost to the particular authority. At present, Metro Toronto's Industrial Waste Control Program costs approximately $702,600. a year. It must be noted here that this same group monitors industrial effluents discharging organic wastes, amenable to treatment, but in excess of the by-law. Agreements are arranged that re-imburses the Municipality for the additional costs incurred in the treatment of these over strength wastes. This cost, however, only reflects the labour and lab costs associated with sampling and testing mainly for heavy metals. These are the easier and less expensive tests. Appreciating that our existing facility cannot handle the existing load as well as the additional

number of samples that will result, we are presently engineering for a considerably larger laboratory including the more sophisticated equipment needed to test for the toxic contaminants. If industry and the public sector all try to have the work carried out in the existing private laboratories, it is doubtful that they could handle the load - at least for a considerable time. With the amount of work required in this area, we feel that we are better to continue to do our own lab work. The cost for this activity including both capital and current expenses will be quite considerable. Even when the building and the equipment has been acquired, there will still be an annual cost for operation and depreciation. Only the largest municipalities can hope to do this economically, necessitating some form of regional facility for the remainder.

Will the Province be prepared to set up such facilities?

One of the key components of the MISA program will be the setting of the effluent limits. It is proposed to use the BAT (best available technology economically achievable) approach along with a water quality impact study on the receiving body of water. It is to be hoped that the Province will allow the municipalities to use whatever technology they choose, and only demand that the final results achieve the desired standard. There is no question that water quality assessments will have to be undertaken to ascertain the impact of the effluents on the water quality. These studies are also expensive. Such studies also present problems as to who must conduct them and how do you solve the problem of interaction between many discharges. It would seem most desirable for the Ministry to co-ordinate and fund these assessments.

The MISA program will require both abatement and enforcement. The limits to be set will have to have legal status to facilitate enforcement. The local authority could be faced with the necessity of increasing their enforcement staff considerably in order to properly enforce the standards set by the Ministry. Through Environment Canada, the MOE and the MEA a new Model Industrial

Sewer Use By-law is being prepared. comments have been requested from Municipalities and industrial associations with respect to the terms of this proposed by-law. The final version should be available shortly. It was stated that limits set for industries discharging to Municipal systems will be enforced, although it does not state how this will be accomplished. We presume it will be up to the municipality. It also states that industries may be required to pretreat their wastes. As has been stated previously, we believe they must be made to adhere to the same conditions as those industries discharging directly to a stream or lake.

If the municipality is to play its part in the MISA program, then it must have the authority it needs to do so. Information as to the products used in the production process and the wastes that will be generated must be made available to them. As of this date, a Municipality can only ask for this information. If the industry does not choose to divulge it, there is nothing the Municipality can do to force them to give the information. With this information and the actual results from the self-monitoring by the industries, a municipality will be able to identify more quickly the source of contaminants entering the treatment plant and require that the necessary pre-treatment be installed, or move to stop the discharge by legal means.

One factor that is causing considerable concern for all authorities who run wastewater treatment plants, is the health of their workers. Even if a treatment plant does remove some of these contaminants in the process, what effect are these wastes having on the environment in which the employee must work. Staff are now demanding tests to check such things as the levels of PCBs in their blood, the ability of their lungs to perform and the cause and possible permanent effect of rashes with which they sometimes are plagued. Many municipalities are now looking at high costs for health studies to try and answer the growing number of queries on this topic. Again, removal at source solves this vexing problem.

As the MISA program proceeds, it is imperative that good liaison is maintained between the Province and the municipalities in order that the technical staffs of both have time to review and set the parameters to produce a sound and economically viable program. It is proposed to have the effluent regulations in place by the end of 1989. Considering the varying mix of commercial, industrial and domestic waste that can enter any one plant, it presents a large problem to produce the regulations for the municipal sector. It is our understanding that the public will have complete access to data on contaminant discharges and on the effluent limits proposed. Many environmental groups are represented on the Advisory Committee and this will be one method of obtaining public participation. The other most obvious area must be the A.M.O. Every citizen has access to the local councillor and through them to the AMO who will then see that those concerns are brought to the Province's attention. We would hope and expect that the Ministry will consult with this body every step of the way. In order for the MISA program to be a success, it must have the support and confidence of the public. They must be assured that the Province has set proper standards and will ensure that adequate policing is accomplished. This will require the combined efforts of all agencies involved in water pollution control.

Although our comments have in general been slanted from a Municipal point of view, we would note, however, that the Ministry, on behalf of local governments, runs many treatment plants. We would think that in that area they are facing the same concerns.

Municipalities do not want to seem as if they are crying before they are hurt. However, they do have legitimate concerns with respect to the financial burden that MISA can represent.

We wholeheartedly support the ideals and objectives of the MISA Program and are desirous of playing our part in it.

In summary, we would like to see the Province:

1. Assist us financially and where required technically in carrying out our part.
2. Require all industry to monitor their effluents and where necessary pretreat their wastes at source.
3. Assume responsibility for water quality impact studies.
4. Consider some form of regional facility for the analysis of samples collected by the local municipalities with the cost for the analysis borne by the Municipality.
5. Evaluate the effects of air borne pollutants on the receiving waters. (I J C suggests they represent 1/3 of total) and not expect that improved effluents alone will solve the problem.
6. Ensure public participation in the MISA Program.

THIRTY-FOURTH ONTARIO INDUSTRIAL WASTE CONFERENCE

Toronto Prince Hotel
June 14-17, 1987

REGISTERED DELEGATES

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M8V 3S4

Calver, B. A.
X-Pert Metal Finishing Ltd.
1232 Dillon Rd.
Burlington, Ont.
L7M 1N3

Cameron, D.
Environment Canada

Ottawa, Ont.
K1A 1C8

Cameron, W. L.
Cyanamid Canada Inc.
4001 4th Ave. - Box 2118
Niagara Falls, Ont.
L2J 6Z2

Campbell, D.
Regional Municipality of Niagara
P.O. Box 1042
Thorold, Ont.
L2V 4T7

Campbell, L.
CIL Inc.
2101 Hadwen Rd.,Sheridan Pk.
Mississauga, Ont.
L5K 2L3

Camplong, C. D.
Union Carbide Can. Ltd.
123 Eglinton Ave. E.
Toronto, Ont.
M4P 1J3

Canning, P.
Zenon Environmental Inc.
845 Harrington Court
Burlington, Ont.
L7N 3P3

Caplice, D. P.
Ministry of the Environment
14th Fl. - 135 St. Clair W.
Toronto, Ont.
M4V 1P5

Caranci, M.
Environment Ontario
119 King St. W. Box 2112
Hamilton, Ont.
L8N 3Z9

Carey, P.
Lever Brothers Limited
1 Sunlight Park Rd.
Toronto, Ont.
M4M 1B6

Carter, R.
Bakelite Thermosets Ltd.
621 Dundas St.
Belleville, Ont.
K8N 5C5

Castel, A.
Ministry of the Environment
14th Fl. - 135 St. Clair W.
Toronto, Ont.,
M4V 1P5

Caswell, C. B.
Polysar Limited
201 N. Front St.
Sarnia, Ont.
N7T 7V1

Cave, B.
Ministry of the Environment
445 Albert St. E.
Sault Ste. Marie, Ont.
P6A 2J9

Chant, D. A.
Ontario Waste Management Corp.
2 Bloor St W.-11th Fl.
Toronto, Ont.
M4V 3E2

Chart, T.
MacLaren Engineers Inc.
33 Yonge St.
Toronto, Ont.
M5E 1E7

Cheetham, M. F.
Ministry of the Environment
5th Fl. - 7 Overlea Blvd.
Toronto, Ont.
M4H 1A8

Cheung, L.
Ford Motor Co. Of Can. Ltd.
Oakville Assembly Plant
Oakville, Ont.
L6J 5C9

Christie, M.
General Motors of Canada
215 William St. E.
Oshawa, Ont.
L1G 1K7

Clough, D.
Municipal Engineers Assoc. of Ont.
439 University Ave.-10th Fl.
Toronto, Ont.
M5G 1Y8

Coburn, J.
ZENON Environmental Inc.
845 Harrington Court
Burlington, Ont.
L7N 3P3

Compton, W. D.
Canadian Industries Ltd.
400 Jones Rd., P.O. 19910
Stoney Creek, Ont.
L8G 3Z1

Condlln, F. C.
Reg. Munic. of Peel
10 Peel Centre Dr.
Brampton, Ont.
L6T 4B9

Conrad, L. G.
Regional Municiality of Peel
10 Peel Centre Dr.
Brampton, Ont.
L6T 4B9

Constantine, T.
MacLaren Engineers Inc.
33 Yonge St.
Toronto, Ont.
M5E 1E7

Cook, D. B.
Waste Systems Ltd
155 Ardelt Ave.,P.O.Box 10
Kitchener, Ont.
N2G 3W9

Cook, J. D.
ESSO Petroleum Canada
55 St. Clair Ave. W.-Rm.4148
Toronto, Ont.
M5W 2J8

Cousens, R.
Petro-Canada Products
385 Southdown Rd.
Mississauga, Ont.
L5J 2Y3

Cowan, J.
Woodington Systems Ltd.
P.O. Box 100
Thorold, Ont.
L2V 3Y8

Crabtree, P.
Ministry of the Environment
6th Fl.-40 St. Clair Ave W.
Toronto, Ont.
M4V 1P5

Crawford, B.
Kodak Canada Inc.
3500 Eglinton Ave. W.
Toronto, Ont.
M6M 1V3

Crouse, A.
Nova Scotia Dept. of Env.
P.O. Box 2107
Halifax, Nova Scotia
B3J 3B7

Cruickshank, J.
Woodington Systems Ltd.
P.O. Box 100
Thorold, Ont.
L2V 3Y8

Crump, D.
Waste Management Br., MOE
5th Fl. - 40 St. Clair W.
Toronto, Ont.
M4V 1M2

Crutcher, A. J.
Conestoga Rovers & Associates
651 Colby Dr.
Waterloo, Ont.
N2V 1C2

Cunningham, J. D.
Cyanamid Canada Inc.
P.O. Box 240
Niagara Falls, Ont.
L2E 6T4

Cutforth, B.
Ontario Hydro
700 University Ave. A2-C8
Toronto, Ont.
M5G 1X6

Czerneda, R.
Technical Service Labs.
1301 Fewster Dr.
Mississauga, Ont.
L4W 1A2

Daneliuk, J.
Philip Enterprises Inc.
P.O.Box 423, Stn. B
Hamilton, Ont.
L8G 1R8

Davis, H.
Eaglebrook Environmental
Ste. 208 - 2 Lansing Square
North York, Ont.
M2J 4P8

Dawe, R.
Tricil (Sarnia) Ltd.
Ste. 502 - 265 Front St. N.
Sarnia, Ont.
N7T 7X1

Dawson, C.
Ontario Hydro
700 University Ave.,H10 D1
Toronto, Ont.
M5G 1X6

den Bak, T.
Kimberly-Clark of Can. Ltd.
Box 790
Huntsville,Ont.
P0A 1K0

Donaldson, W.
Continuous Colour Coat Ltd.
1430 Martin Grove Rd.
Rexdale, Ont.
M9W 4Y1

Drowley, W. B.
MacLaren Plansearch
33 Yonge St.
Toronto, Ont.
M5E 1E7

Duchominsky, R
City of Winnipeg
1500 Plessis Rd.-Box 178
Winnipeg, Man.
R2C 2Z9

Duffus, G. S.
Westinghouse Canada
120 King St.W. Box 510
Hamilton, Ont.
L8N 3K2

Dulny, J. S.
Ministry of the Environment
4th Fl. - 7 Overlea Blvd.
Toronto, Ont.
M4H 1A8

Duncan, C. E.
Ministry Of the Environment
880 Bay St.-4th Fl.
Toronto, Ont.
M5S 2Z8

Dunn, P. K.
Reg.Mun.Hamilton/Wentworth
71 Main St.W.,Dept.Eng.
Hamilton, Ont.
L8N 3T4

Durham, F.
Ministry of the Environment
985 Adelaide St. S.
London, Ont.
N6E 1V3

Eedy, W.
Beak Consultants Ltd.
6870 Goreway Dr.
Mississauga, Ont.
L4V 1P1

Eisler, H.
Stelco Inc.
P.O. Box 2030
Hamilton, Ont.
L8N 3J1

Emberson, C.
Enpoco Ltd.
405 Midwest Rd.
Scarborough, Ont.
M1P 3A6

Epp, P.
Giffels Associates Ltd.
30 International Blvd.
Rexdale, Ont.
M9W 5P3

Etheridge, J.
Ont. Waste Management Corp.
11th Fl. - 2 Bloor St. W.
Toronto, Ont.
M4W 3E2

Fairn, B.
C.B. Fairn & Associates Ltd.
18 Greengate Rd.
Don Mills, Ont.
M3B 1E8

Fairn, C.
C. B. Fairn & Associates Ltd.
18 Greengate Rd.
Don Mills, Ont.
M3B 1E8

Faust, J.
Corp. City of Windsor
P.O. Box 1607
Windsor, Ont.
N8W 4W0

Ferguson, R.
Metro Toronto
439 University Ave.
Toronto, Ont.
M5G 1Y8

Filipovich, D.
Union Carbide Canada Ltd.
123 Eglington Ave E.
Toronto, Ont.
M4P 1J3

Finley, G.
PPG Canada Inc.
3730 Lakeside Blvd. W.
Toronto, Ont.
M8W 1P3

Fitzgerald, A.
Northern Telecom Canada
304 East Mall
Islington, Ont.
M9B 6E4

Flewitt, F.
Blackstone Industrial Products Ltd.
533 Romeo St. S.
Stratford, Ont.
N5A 6T7

Flynn, T.
McDonnell Douglas Canada Ltd.
P.O.Box 6013, T.O. AMF
Toronto, Ont.
L5P 1B7

Fowle, T.
Simcoe Engineering Group
345 Kingston Rd.
Pickering, Ont.
L1V 1A1

Fracassi, A.
Philip Enterprises Inc.
P.O.Box 423, Stn. B
Hamilton, Ont.
L8G 1R8

Franciosa, M.
Ministry of the Environment
135 St. Clair Ave. W.
Toronto, Ont.
M4V 1P5

Francis, R.
Metalloy
15 Wallsend Dr.
West Hill, Ont.
M1E 3X6

Friar, R. S.
Alcan Smelters & Chemicals
1188 West, Sherbrooke St.
Montreal, PQ.
H3A 3G2

Fricker, B.
Brydor Limited
Box 115
Don Mills, Ont.
M3C 2R6

Friendly, D.
Petro Canada Products
P.O. Box 520
Oakville, Ont.
L6J 5B5

Furlong, J.
Decon
Ste 500 - 7030 Woodbine Ave.
Markham, Ont.
L3R 1A2

Garcia-Lee, V.
Ontario Hydro
700 University Ave. A2-C7
Toronto, Ont.
M5G 1X6

Garden, S.
Environment Canada
25 St. Clair Ave. E.-7th Fl.
Toronto, Ont.
M4T 1M2

Gardiner, E.
Ontario Mining Association
111 Richmond St. W. Ste.1114
Toroto, Ont.
M5H 2G4

Gartner, J.
Gartner-Lee Ltd.
140 Renfrew Dr.
Markham, Ont.
L3R 6B3

Genest-Conway, B.
Indian & Northern Affairs Canada
Box 1500
Yellowknife, NWT
X1A 2R3

German, R.
MacLaren Engineers Inc.
33 Yonge St.
Toronto, Ont.
M5E 1E7

Gibson, W. J.
Ministry of the Environment
199 Larch St.
Sudbury, Ont.
P3E 5P9

Giles, J. W.
Ministry of the Environment
14th Fl. - 135 St. Clair W.
Toronto, Ont.
M4V 1P5

Glenn, B.
Corpus Information Services
1450 Don Mills Rd.
Don Mills, Ont.
M3B 2X7

Glover, E. B.
IWT-HIMSLEY International Ltd.
Ste 305 - 250 Merton St.
Toronto, Ont.
M4S 1B1

Glover, S.
Ministry of the Environment
12th Fl. - 135 St. Clair W.
Toronto, Ont.
M4V 1P5

Gorber, D.
SENES Consultants Limited
499 McNicoll Ave.
Willowdale, Ont.
M2H 2C9

Gotts, R. M.
Ministry of the Environment
5th Fl. - 40 St. Clair W.
Toronto, Ont.
M4V 1M2

Greenall, M.
Ontario Hydro
700 University Ave. (A2C7)
Toronto, Ont.
M5G 1Z5

Greenshields, J.
SUNCOR
Box 307
Sarnia, Ont.
N7T 7J3

Green, Larry B.
Kodak Canada Inc.
3500 Eglinton Ave. W.
Toronto, Ont.
M6M 1V3

Greig, B.
Chem-King Inc.
Snow Valley Rd.
Barrie, Ont.
L4M 4S5

Grey, S.
Kodak Canada Inc.
3500 Eglinton Ave. W.
Toronto, Ont.
M6M 1V3

Griffiths, R.
Ont. Waste Management Corp.
11th Fl.-2 Bloor St. West
Toronto, Ont.
M4W 3E2

Guido, S.
Chrysler Canada Ltd.
2199 Chrysler Center
Windsor, Ont.
N9A 4H6

Guscott, D.
Ministry of the Environment
Box 820, 133 Dalton Ave.
Kingston, Ont.
K7L 4X6

Haasz, T.
Municipality of Metro. Toronto
439 University Ave.-10th Fl.
Toronto, Ont.
M5G 1Y8

Hailes, C. E.
Texaco Canada Inc.
1210 Sheppard Ave. E.
Willowdale, Ont.
M2K 2S8

Hall, J.
Ontario Hydro
700 University Ave. A8-E2
Toronto, Ont.
M5G 1X6

Hall, R. H.
(Consultant)
320 Dalewood Dr.
Oakville, Ont.
L6J 4P5

Hallett, D. J.
Eli Eco Laboratories
Rockwood, Ont.
N0B 2K0

Hansen, P.
Chrysler Canada Ltd.
Box 1621-CIMS 240-01-32
Windsor, Ont.
N9A 4H6

Hansler, B.
Ministry of the Environment
Box 2112
Hamilton, Ont.
L8N 3Z9

Hanson, A. F.
Outboard Marine Corp.
100 Sea-Horse Dr.
Waukegan, Illinois
60085

Harries, R.
Canviro Consultants
Suite 600, 180 King St. S.
Waterloo, Ont.
N2J 1P8

Harwood, J. G.
Courtaulds Canada
1150 Montreal Rd.
Cornwall, Ont.
K6H 5S2

Hawke, R.
City of Orillia
Box 340
Orillia, Ont.
L3V 3L9

Hawken, J.
H. Sutcliffe Limited
Box 1208
New Liskeard, Ont.
P0J 1P0

Hawley, J.
Ministry of the Environment
4th Fl.-1 St. Clair Ave. W.
Toronto, Ont.
M4V 1K6

Hedley, C.
City of Cornwall
861 2nd St. West
Cornwall, Ont.
K6H 5T9

Heidbuurt, J.
Maple Leaf Mills Ltd.
R. R. #1
Moorefield, Ont.
N0G 2K0

Hellerman, P.
Township of Harwich
P.O. Box 89
Blenheim, Ont.
N0P 1A0

Henderson, D.
Tricil (Sarnia) Ltd.
89 The Queensway W.
Mississauga, Ont.
L5B 2V2

Herrnberger, C.
American Motors of Canada Inc.
Box 2500, 400 Renault Blvd.
Brampton, Ont.
L6T 4Y6

Heyink, H.
Ratcliff's (Can. Ltd.)
10537 Yonge St.
Richmond Hill, Ont.
L4C 3C5

Hickman, D.
Waste Management Br., MOE
5th Fl. - 40 St. Clair W.
Toronto, Ont.
M4V 1M2

Hicks, J.
Ont. Waste Management Corp.
'11th Fl. - 2 Bloor St. W.
Toronto, Ont.
M4W 3E2

Higgins, B.
Syntath, Service of Tricil (Sarnia)
P.O. Box 188
Thorold, Ont.
L2V 3Y9

Hilditch, T.
Gartner Lee Limited
140 Renfrew Dr.
Markham, Ont.
L3R 6B3

Hockett, W.
General Motors of Canada
Park Rd. South
Oshawa, Ont.
L1G 1K7

Hodder, J. W.
Nfld. Dept. of Environment
P.O.Box 4750, St. John's
St. John's, Nfld.
A1C 5T7

Hogg, W. J.
PACE
1202-275 Slater St.
Ottawa, Ont.
K1P 5H9

Hoglund, G.
Ontario Hydro
700 University Ave.
Toronto, Ont.
M5G 1Z5

Holman, W. C.
Conlin Eng. & Planning
28 Viking Dr.
St. Catharines, Ont.
L2M 2V3

Hoornweg, D.
City of Guelph
City Hall, 59 Garden St.
Guelph, Ont.
N1H 3A1

Hoshowsky, D.
Retek Resource Recovery
66 Mohawk #18, Box 1584
Brantford, Ont.
N3T 5V6

Hunter, E.
Tricil (Sarnia) Ltd.
Ste. 502 - 265 Front St. N.
Sarnia, Ont.
N7T 7X1

Insell, M.
Microbe Corporation
85 Midpark Rd.
London, Ont.
N6N 1B2

Isaac, A.
Taro Properties Inc.
341 1st Rd. W.
Hamilton, Ont.
L8J 1W4

Jackman, D.
Ontario Hydro
700 University Ave.
Toronto, Ont.
M5G 1X6

Jackson, D. K.
Consultant
26 Sagewod Dr.
Don Mills, Ont.
M3B 3G5

Jedlicsek, F.
C.B.C. Toronto 5
500 Church St.
Toronto, Ont.
M5C 2G7

Jeffs, D.
Ministry of the Environment
135 St. Clair Ave. W.
Toronto, Ont.
M4V 1P5

Johnston, E.
Tricil
1829 Allanport Rd.
Thorold, Ont.
L2V 3Y9

Kaegi, H. P.
Kaegi & Associates Ltd.
110 Church St.-3rd. Fl.
Toronto, Ont.
M5C 2G7

Kantor, M.
Industrial Development & Management
300 Giles Blvd., Box 390
Windsor, Ont.
N9A 4C4

Kawasaki, J.
Ministry of the Environment
4th Fl. - 7 Overlea Blvd.
Toronto, Ont.
M4H 1A8

Keith, R. E.
Region of Durham
105 Consumers Dr.
Whitby, Ont.
L1N 6A3

Kelleher, M.
Canviro Consultants
2233 Argentia Rd. - Ste. 302
Toronto, Ont.
L5N 2X7

Kemp, G. D.
Komline-Sanderson Ltd.
72 Orenda Rd.
Brampton, Ont.
L6W 1W1

Kennedy, J.
WCI Waste Conversion Inc.
2349 Fairview St.
Burlington, Ont.
L7R 2E3

Khettry, R.
Waste Management Br., MOE
5th Fl. - 40 St. Clair W.
Toronto, Ont.
M4V 1M2

Killackey, B.
Waste Management Br., MOE
5th Fl. - 40 St. Clair W.
Toronto, Ont.
M4V 1M2

Kishbaugh, B.
Giffels Associates Ltd.
30 International Blvd.
Rexdale, Ont.
M9W 5P3

Klag, M.
Dofasco Inc.
P.O. Box 460
Hamilton, Ont.
L8N 3J5

Klein, B.
Totten Sims Hubicki Assoc.
1500 Hopkins St.
Whitby, Ont.
L1N 2C3

Klint, S.
Tricil Limited
P.O. Box 2518
Charlottetown, P.E.I.
C1A 8C2

Koletar, F. L.
Work Wear Corp. of Can.
17 Benton Rd.
Toronto, Ont.
M6M 3G3

Kosalle, J.
Maple Leaf Mills Ltd.
R. R. #1
Moorefield, Ont.
N0G 2K0

Kowalchuk, K.
Intergrated Explorations
Box 1385, 189 McCurdy Rd.
Guelph, Ont.
N1H 6N8

Kruzins, A.
Dofasco Inc.
P. O. Box 460
Hamilton, Ont.
L8N 3J5

Kuczynski, L
Ont. Waste Management Corp.
11th Fl. - 2 Bloor St. W.
Toronto, Ont.
M4W 3E2

Kurtz, J.
Ministry of the Environment
4th Fl.-880 Bay St.
Toronto, Ont.
M5S 1Z8

Kurys, J. G.
M. I. T. T.
900 Bay St.5th Fl.
Toronto, Ont.
M7A 2E1

Kustan, E.
Marshall Macklin Monaghan Limited
275 Duncan Mill Rd.
Don Mills, Ont.
M3B 2Y1

Kutzelnig, E.
Waste Management Br., MOE
5th Fl. - 40 St. Clair W.
Toronto, Ont.
M4V 1M2

Lalonde, C. A.
Tricil Ltd.
89 Queensway W.
Mississauga, Ont.
L5B 2V2

Lalonde, M.
Alcan Smelters & Chemicals Ltd.
P.O. Box 1500
Jonquiere, Que.
G7S 4L2

Laratta, E.
Ontario Hydro
700 University Ave.,H10 Fl
Toronto, Ont.
M5G 1X6

Laughton, P.
R.V. Anderson Assoc. Ltd.
1210 Sheppard Ave. E.
Willowdale, Ont.
M2K 1E3

Lauridsen, S. A.
DuPont Canada Inc.
P.O. Box 611
Maitland, Ont.
K0E 1P0

Lavely, L.
Research Cotrell (Can.)
Suite 212-6701 W 64th St.
Shawnee Mission, Kansas
66202

Leckie, J.
Daily Commercial News
280 Yorkland Blvd.
Willowdale, Ont.
M2J 4C6

Leech, B.
Gartner Lee Limited
140 Renfrew Dr.
Markham, Ont.
L3R 6B3

Legati, S.
Tonolli Canada Ltd.
1333 Tonolli Rd.
Mississauga, Ont.
L4Y 4C2

Lepine, R.
General Chemical
106 Venetian Dr.
Amherstburg, Ont.
N9V 3A2

Lianga, C.
PAL'S
225 Church St.
St. Catharines, Ont.
L2N 4M6

Lightowlers, W.
Ont. Waste Management Corp.
11th Fl. - 2 Bloor St. W.
Toronto, Ont.
M4W 3E2

Lim, V.
Municipality of Metro. Toronto
439 University Ave.
Toronto, Ont.
M5G 1Y8

Linzon, S.
Ministry of the Environment
4th Fl.-880 Bay St.
Toronto, Ont.
M5S 1Z8

Llewellyn, S.
Environment Canada
25 St. Clair Ave. E.-7th Fl.
Toronto, Ont.
M4T 1M2

Lockhart, B. L.
Esso Chemical Canada
2300 Yonge St.
Toronto, Ont.
M5W 1K3

Longland, M.
MacLaren Engineers Inc.
33 Yonge St.
Toronto, Ont.
M5E 1E7

Lunansky, J.
Manitoba Environment
BLGD 2-139 Tuxedo
Winnipeg, Manitoba
R3N 0H6

Lyness, R. H.
Ministry of the Environment
133 Dalton Ave.
Kingston, Ont.
K7K 6C2

Lyon, K.
Four Elements Inc.
70 Hanlan Rd. Unit 1
Woodbridge, Ont.
L4L 3P6

Mackay, G. D.
Browning-Ferris Industries Ltd.
161 Bridgeland Ave.
Toronto, Ont.
M6A 1Z1

Mackie, G.
Canadian Dredge & Dock
29 Gervais Dr.
Don Mills, Ont.
M3C 1Z1

MacLeod, D.
Northern Telecom Canada
304 East Mall
Islington, Ont.
M9B 6E4

Madill, K.
Waste Management Br., MOE
5th Fl. - 40 St. Clair W.
Toronto, Ont.
M4V 1M2

Mandzy, T.
Bristol-Myers Mfg.
99 Vanderhoof Ave.
Toronto, Ont.
M4G 2H6

Manuel, J.
Waste Management Br., MOE
5th Fl. - 40 St. Clair W.
Toronto, Ont.
M4V 1M2

Marcinkowski, J.
DeVilbiss Canada Ltd.
1 Wood St.
Barrie, Ont.
L4M 4V6

Marck, L.
Steetley Industries Ltd.
447 Moxley Rd. S.
Dundas, Ont.
L9H 5E2

Mardirossian, G.
Giffels Associates Ltd.
30 International Blvd.
Rexdale, Ont.
M9W 5P3

Maruska, R.
Ontario Hydro
700 University Ave. A2-C7
Toronto, Ont.
M5G 1X6

Marvan, I.
Dearborn
3451 Erindale Station Rd.
Mississauga, Ont.
L5A 3T5

Maslen, L.
Calgon Carbon Canada
6303 Airport Rd. Ste 304
Mississauga, Ont.
L4V 1R8

Matys, V.
Gore & Storrie Ltd.
1670 Bayview Ave.
Toronto, Ont.
M4G 3C2

Mayhew, A.
Mosaic Chemical Corp.
5369 Maingate Drive
Mississauga, Ont.
L4W 1G6

McGuinness, E.
Hamilton Spectator
44 Frid St.
Hamilton, Ont.
L8N 3G3

McIelwain, T.
Golder Associates
3151 Wharton Way
Mississauga, Ont.
L4X 2B6

McKenzie, C. D.
Esso Petroleum Canada
55 St. Clair Ave. W.
Toronto, Ont.
M4V 2Y7

McLeod, R. M.
Ministry of the Environment
14th Fl. - 135 St. Clair W.
Toronto, Ont.
M4V 1P5

McManus, J.
Calgon Carbon Canada Inc.
6303 Airport Rd.-Ste. 304
Mississauga, Ont.
L4V 1E3

McMillan, A.
Ontario Hydro
700 University Ave. (A2-C7)
Toronto, Ont.
M5G 1X6

McPhee, S.
Ministry of the Environment
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Toronto, Ont.
M4V 1P5

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Intergrated Explorations
189 McCurdy Rd.-Box 1385
Guelph, Ont.
N1H 6N8

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Ministry of the Environment
4th Fl.-7 Overlea Blvd.
Toronto,Ont.
M4H 1A8

Miner, D.
Ont. Waste Management Corp.
11th Fl.-2 Bloor St. W.
Toronto, Ont.
M4W 3E2

Minor, J. D.
City of Scarborough
55 Town Centre Court Ste. 800
Scarborough, Ont.
M1P 4Y2

Mooij, H.
H. Mooij & Associates Ltd.
770B Bath Rd.
Kingston, Ont.
K7M 4Y2

Morris, J. V.
Maclaren Plansearch Inc.
33 Yonge St.
Toronto, Ont.
M5E 1G4

Moskal, D.
Reg. Munic. of Peel
10 Peel Centre Dr.
Brampton, Ont.
L6T 4B9

Nesbitt, B.
Tricil (Sarnia) Ltd.
Ste. 502 - 265 Front St. N.
Sarnia, Ont.
N7T 7X1

Newman, C.
Nabisco Brands Ltd.
1 Dundas St. W.
Toronto, Ont.
M5G 2A9

Ng, W.
Waste Management Br., MOE
5th Fl. - 40 St. Clair W.
Toronto, Ont.
M4V 1M2

Niwa, K.
DeVilbiss Canada Ltd.
1 Wood St.
Barrie, Ont.
L4M 4V6

Nowina, R. F.
Tricil Ltd.
89 Queensway W.
Mississauga, Ont.
L5B 2V2

Nutt, S.
Canviro Consultants
Ste. 600-180 King St. S.
Waterloo, Ont.
N2J 1P8

Nyitrai, B.
Town of Vaughan
2141 Major McKenzie Dr.
Maple, Ont.
L0G 1E0

Nyp, H.
Sanivan
P. O. 2240
Sarnia, Ont.
M7T 7L7

Orchard, D.
Corpus Information Services
1450 Don Mills Rd.
Don Mills, Ont.
M3B 2N7

Osborne, R.
Atomic Energy of Canada Ltd.
Chalk River Nuclear Lab.
Chalk River, Ont.
K0J 1J0

Osmond, D.
Gartner Lee Limited
140 Renfrew Dr.
Markham, Ont.
L3R 6B3

O'Neill, T.
Gartner Lee Limited
140 Renfrew Dr.
Markham, Ont.
L3R 6B3

Pagel, J.
Ministry of the Environment
12th Fl.-135 St. Clair Ave. W.
Toronto, Ont.
M4V 1P5

Paquet, J.
CIL Inc. Cornwall Works
300 Brookdale Ave.,P.O.1299
Cornwall, Ont.
K6H 5V4

Pascoe, D. J.
Environment Canada
25 St. Clair Ave. E.
Toronto, Ont.
M4T 1M2

Patterson, D.
National Silicates Ltd.
Box 69 Stn. N.
Toronto, Ont.
M8V3S4

Patterson, J. B.
Ministry of the Environment
135 St. Clair Ave W.
Toronto, Ont.
M4V 1P5

Paz, Antonio J.
Nabisco Brands Ltd.
1 Dundas St. W.
Toronto, Ont.
M5G 2A9

Pestowka, M. A.
North American Plastics
Box 124
Wallaceburg, Ont.
N8A 4L5

Pinder, E. C.
Bd. of Trade of Metro Toronto
P.O.Box 60, 3 1st Can. Place
Toronto, Ont.
M5X 1C1

Pinkerton, B.
Marshall Macklin Monaghan Limited
275 Duncan Mill Road
Don Mills, Ont.
M3B 2Y1

Pioro, K. M.
Humber College
Humber College Blvd.
Rexdale, Ont.
M9W 5L7

Pleasance, G.
On-Site/Energy Pathway
1179 King St. W.-Ste.110
Toronto, Ont.
M6K 3C5

Poy, M.
Magna Technologies
36 Apple Creek Blvd.
Markham, Ont.
L3R 4Y4

Radcliffe, S.
Waste Management Br., MOE
5th Fl. - 40 St. Clair W.
Toronto, Ont.
M4V 1M2

Raven, K.
Intera Technologies Ltd.
600-1525 Carling Ave.
Ottawa, Ont.
K1Z 8R9

Rayner, J.
Ministry of the Environment
112 King St. West
Hamilton, Ont.
N1S 1C5

Reades, D.
Golder Associates
3151 Wharton Way
Mississauga, Ont.
L4X 2B6

Rebin, E.
Calgon Carbon Corp.
P.O. Box 717
Pittsburgh, PA.
15230

Redhead, R.
Tricil (Sarnia) Ltd.
89 The Queensway W.
Mississauga, Ont.
L5B 2V2

Reed, J. W.
Texaco Canada
90 Wynford Dr.
Don Mills, Ont.
M3C 1K4

Reid, J. D.
Napier-Reid Ltd.
Unit 2 - 10 Alden Ave.
Markham, Ont.
L3R 2S1

Reid, J. M.
BCL Canada
P.O. Box 159
Cornwall, Ont.
K6H 5S9

Rennie, N.
Morrison Beatty Ltd.
4500 Dixie Rd., Unit 12A
Mississauga, Ont.
L4W 1V7

Reynolds, A.
Woodington Systems Inc.
P.O. Box 100
Thorold, Ont.
L2V 3Y8

Richmond, J.
Ont. Waste Management Corp.
11th Fl. - 2 Bloor St. W.
Toronto, Ont.
M4W 3E2

Riddle, M.
Monenco Consultants Ltd.
Ste. 500 - 155 Rexdale Blvd.
Rexdale, Ont.
M9W 5Z8

Robins, J.
Pollution Probe
12 Madison Ave.
Toronto, Ont.
M5R 2S1

Rocchi, J.
Retek Resource Recovery Inc.
P.O. Box 1584
Brantford, Ont.
N3T 5V6

Rocoski, G.
Waste Management Br., MOE
5th Fl. - 40 St. Clair W.
Toronto, Ont.
M4V 1M2

Rodgers, K.
Canada Centre for Inland Waters
867 Lakeshore
Burlington, Ont.
L7S 1A1

Rodricks, L.
PPG Canada Inc.
880 Avonhead Rd.
Mississauga, Ont.
L5J 2Z5

Rostern, P.
Ministry of the Environment
119 King St. W., 12th Fl.
Hamilton, Ont.
L8N 3Z9

Rothfuss, R.
Reg. Munic. of Peel
10 Peel Centre Dr.
Brampton, Ont.
L6T 4B9

Roussel, P.
Ministry of the Environment
139 George St. N.
Peterborough, Ont.
K9J 3G6

Russell, B.
CIL Paints
1300 Castlefield Ave.
Toronto, Ont.
M6B 1G5

Ruttan, L. W.
Celanese Canada Inc.
Postal Bag 2800
Kingston, Ont.
K7L 4Z8

Ryan, J.
Ontario Hydro
700 University Ave. A2-C8
Toronto, Ont.
M5G 1X6

Schmidt, E.
Ont. Waste Management Corp.
2 Bloor St. W.-2nd Fl.
Toronto, Ont.
M4W 3E2

Seguin, A.
Chrysler Canada Ltd.
P.O. Box 1621
Windsor, Ont.
N9A 4H6

Shah, Z. A.
Canadian Standards Assoc.
178 Rexdale Blvd.
Rexdale, Ont.
M9W 1R3

Shaw, J.
Mosaic Chemical Corp.
5369 Maingate Dr.
Mississauga, Ont.
L4W 1G6

Shenfeld, L.
Ministry of the Environment
125 Resources Rd.-P.O. 213
Toronto, Ont.
M9W 5L1

Sherbin, G.
Environment Canada
25 St. Clair Ave. E.-7th Fl.
Toronto, Ont.
M4T 1M2

Shikaze, K.
Environment Canada
25 St. Clair Ave. E.-7th Fl.
Toronto, Ont.
M4T 1M2

Shipley, B.
Uniroyal Ltd.
Box 250
Elmira, Ont.
N3B 3A3

Shrives, J.
Environment Canada
13th Fl.-351 St. Joseph Blvd.
Hull, Quebec
K1A 1C8

Simonetti, M.
Southam Communications
1450 Don Mills Rd.
Don Mills, Ont.
M3B 2X7

Skalin, G.
Ministry of the Environment
15 Victoria Ave.
Belleville, Ont.
K8N 1Z6

Skuce, M.
Petro-Sun International Inc.
Ste. 608 - 24 Queen St. E.
Brampton, Ont.
L6V 1A3

Sladen, P.
Marshall Macklin Monaghan Ltd.
275 Duncan Mill Rd.
Don Mills, Ont.
M3B 2Y1

Slaine, D.
Gartner Lee Limited
140 Renfrew Dr.
Markham, Ont.
L3R 6B3

Smith, B.
Walker Bros. Quarries
P.O. Box 100
Thorold, Ont.
L2V 3Y8

Smith, E.
Waste Management Br., MOE
5th Fl. - 40 St. Clair W.
Toronto, Ont.
M4V 1M2

Smith, J. E.
Environment Canada
7th Fl.-25 St. Clair Ave. E.
Toronto, Ont.
M4T 1M2

Smith, T.
Intergrated Explorations
189 McCurdy Rd.-Box 1385
Guelph, Ont.
N1H 6N8

Smyth, D.
Golder Associates
3151 Wharton Way
Mississauga, Ont.
L4X 2B6

Smyth, R. A.
L.A.Johnson (Canada) Inc.
10161 Cote de Liesse
Montreal, PQ.
H9P 1A3

Soanes, D.
Acres International
5259 Dorchester Rd.-Box 1001
Niagara Falls, Ont.
L2E 6W1

Somes, W. F.
Polysar Ltd.
Vidal St. S.
Sarnia, Ont.
N7T 7M2

Sorokopas, T.
Environmental Management Corp.
2128 River Rd.
London, Ont.
N6A 4C3

Spersrud, D.
Ford Motor Co.
Rm.640,Box 1899 American Rd.
Dearborn, Michigan
48121

Spira, G.
Chemical Waste Management
327 Riverview Dr.
Youngstown, New York
14174

Staniavljevic, M.
Retek Resource Recovery
66 Mohawk St.
Brantford, Ont.
N3S 2W3

Steele, B.
Dofasco Inc.
P.O. Box 460
Hamilton, Ont.
L8N 3J5

Stegemann, J.
Canada Centre for Inland Waters
867 Lakeshore
Burlington, Ont.
L7S 1A1

Stelzig, A.
Environment Canada
351 St. Joseph Blvd.
Hull, Quebec
K1A 1C8

Stevens, R. D. S.
Solarchem Research
516 Gordon Baker Rd.
Willowdale, Ont.
M2H 3B4

Stewart, A.
Waste Management Br., MOE
5th Fl. - 40 St. Clair W.
Toronto, Ont.
M4V 1M2

Stewart, J. W.
Ontario Liquid Waste Carriers
555 Dixon Rd.
Toronto, Ont.
M9W 1H8

Stewart, R. C.
Ministry of the Environment
Box 2112-12th Fl. 119 King W.
Hamilton, Ont.
L8N 3Z9

Stickney, R.
Canviro Consultants
180 King St. S.-Ste. 600
Waterloo, Ont.
N2J 1P8

Storin, T.
Kimberly-Clark of Can. Ltd.
10 Disco Rd.
Rexdale, Ont.
M9W 5L6

Strang, R.
PPG Canada Inc.
3730 Lakeshore Blvd. W.
Toronto, Ont.
M8W 1P3

Struckholt, K. E.
McDonnell Douglas Canada Ltd.
P.O. Box 6013
Toronto AMF, Ont.
L5P 1B7

St. Denis, L.
Town Of Vankleek Hill
84 Main St.
Vankleek Hill, Ont.
K0B 1R0

St. Jean, R.
Canviro Consultants
180 King St. S.-Ste. 600
Waterloo, Ont.
N2J 1P8

Suddaby, J.
Tricil Ltd.
89 Queensway W.
Mississauga, Ont.
L5B 2V2

Taylor, F.
Ford Motor Co. (Canada)
Box 1672-1 Quality Way
Windsor, Ont.
N9A 6X3

Thadani, V.
Gore & Storrie Ltd.
1670 Bayview Ave.
Toronto, Ont.
M4G 3C2

Tucker, J.
Environmental Management Corp.
2128 River Rd.
London, Ont.
N6A 4C3

Uffen, N.
Eaglebrook Environmental
Ste. 208 - 2 Lansing Square
North York, Ont.
M2J 4P8

Vallery, D.
Ministry of the Environment
112 St. Clair Ave. W.
Toronto, Ont.
M4V 2Y3

Van Egmond, J.
Trow Hydrology Consultants Ltd.
1595 Clark Blvd.
Brampton, Ont.
L6T 4V1

Vance, G.
Conestoga-Rovers Assoc.
651 Colby Dr.
Waterloo, Ont.
N2V 1C2

Varangu, L.
Ont.Waste Exchange,Ont.Rsch.Fnd.
Sheridan Park Reseach Com.
Mississauga, Ont.
L5K 1B3

Veel, A.
Ont. Waste Management Corp.
11th Fl. - 2 Bloor St. W.
Toronto, Ont.
M4W 3E2

Walker, N.
Woodington Systems Ltd.
P.O. Box 100
Thorold, Ont.
L2V 3Y8

Walker, W. I.
M.M. Dillon Ltd.
P.O. Box 495, Stn. B
London, Ont.
N6A 4W7

Wallis, P.
On-Site/Energy Pathways
#110-1179 King St. W.
Toronto, Ont.
M5K 3C5

Wells, W.
M.M. Dillon Ltd.
Box 1850, Stn. A.
Willowdale, Ont.
M2N 6H5

Westerby, G.
Gartner Lee Limited
140 Renfrew Dr.
Markham, Ont.
L3R 6B3

West, C.
Canadian Dredge & Dock
29 Gervais Dr.
Don Mills, Ont.
M3C 1Z1

Whitehead, R.
Enviroclean
320 Adelaide St. S.
London, Ont.
N5Z 3L2

Wiancko, P. M.
Ontario Hydro
700 University Ave. (A8-E1)
Toronto, Ont.
M5G 1X6

Wiber, M.
Noranda Inc.
4 King St W.-Ste. 900
Toronto, Ont.
M5H 3X2

Wightman, A. P.
Tricil (Sarnia) Ltd.
551 Avonhead Rd.
Mississauga, Ont.
L5J 4B1

Wilcox, J. D.
Giffels Associates Ltd.
30 International Blvd.
Rexdale, Ont.
M9W 5P3

Williams, R. A.
Tricil (Sarnia) Ltd.
R. R. #1
Corunna, Ont.
NON 1G0

Williams, R. B.
Ontario Paper Co.
Allanburg Rd.
Thorold, Ont.
L2V 3Z5

Willmott, P.
Halton Reg. Health Dept.
1151 Bronte Rd.
Oakville, Ont.
L6J 6E1

Willms, J.
Willms & Shier
Ste 200-73 Richmond St. W.
Toronto, Ont.
M5H 1Z4

Wilson, J.
AMCA International Ltd.
Ste. 611-200 Ronson Dr.
Rexdale, Ont.
M9W 5Z9

Wolf, K.
Alcan Rolled Products Co.
P.O. Box 2000
Kingston, Ont.
K7L 4Z5

Wrest, K. A.
National-Standard
20 Campbell Rd.
Guelph, Ont.
N1H 1C1

Wright, P.
M.M. Dillon Ltd.
P.O. Box 1850, Stn. A.
Willowdale, Ont.
M2N 6H5

Wysman, J.
Wickes Manufacturing Co. Ltd.
9100 Tecumseh Rd. E.
Windsor, Ont.
N8R 1A3

Yatabe, M.
Gore & Storrie Ltd.
1670 Bayview Ave.
Toronto, Ont.
M4G 3C2

Yee, L.
Hatch Associates
155 Ranee Ave.
Toronto, Ont.
M6A 1N3

Yetmes, M.
57 Langstaff Rd. W.
Richmond Hill, Ont.
L4C 6M9

Yu, P.
Weston Research Center
1047 Yonge St.
Toronto, Ont.
M4W 2L2

Zieman, D.
CIL Paints
1300 Castlefield Ave.
Toronto, Ont.
M6B 1G5

Zikovitz, G.
Ministry of the Environment
5th Fl. - 7 Overlea Blvd.
Toronto, Ont.
M4H 1A8

Zimmerman, L.
St. Lawrence Cement Inc.
2391 Lakeshore Rd. W.
Mississauga,Ont.
L5J 1K1